HYDROLOGIC CHARACTERISTICS OF LAND CLASSES AT PRAIRIE DOG CREEK, MONTANA EMRIA STUDY AREA

by

Gregg C. Lusby

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Rainfall-simulation runs were made at six sites within the Prairie Dog Creek EMRIA study basin. These sites were selected to be typical of different land classes which possess runoff characteristics that are similar over the general extent of that land class. Rainfall-simulation runs were made on the land classes to determine the hydrologic characteristics of the class as baseline data for comparison with future changes which might occur from surface mining. The extent of each land class was determined from areal photographs and a vegetation map prepared by F. A. Branson. Location of simulation sites and vegetative types are shown on the accompanying map (see plate 1, in pocket). A response similar to that obtained from the applied simulated rainfall could be expected from areas of the same vegetative type shown on the map. Although simulation sites were chosen to be representative of the terrain within each vegetative type, runoff and sediment-yield values may have to be altered somewhat to compensate for radically dissimilar slopes and soil depth.

Methods used to obtain the data from each simulation site listed in table 1 are as follows:

1. Runoff—Measured in a Parshall flume with 1-inch throat. Readings of stage were made at 1-minute intervals and converted to discharge in cubic feet per second. From these data, a runoff hydrograph was constructed and total volume of runoff was computed and expressed in inches per unit area. From these data, an infiltration curve was also constructed by subtracting the runoff from the rainfall applied for each 1-minute increment and expressing as the infiltration rate in inches per hour.

2. Precipitation—Measured in a network of rain gages within the study area. Rainfall for the total area was computed using the Thiessen Polygon method. Rainfall is normally applied for a duration of about 45 minutes.

3. Sediment yield—Water samples were obtained from the outflow at 3-minute intervals and were analyzed for sediment concentration. The sediment concentrations were plotted and a concentration curve was drawn between points. From this curve, a concentration was obtained for each minute and was used in conjunction with the discharge for that minute to compute the sediment load. Total sediment load is expressed in pounds and in tons per square mile.

Table 1.--*Data obtained from simulation sites at Prairie Dog Creek, Montana*

Site	1-1	1-2	2-1	2-2	3-1	3-2	4-1	4-2	5-1	5-2	6-1	6-2
Date	7-14-79	7-15-79	7-16-79	7-17-79	7-18-79	7-19-79	7-20-79	7-20-79	8-15-79	8-16-79	8-17-79	8-17-79
Variable												
Area (square feet)	1945	1945	1326	1326	2110	2110	2073	2073	2155	2155	128	128
Weighted mean slope (percent)	10.2	10.2	22.5	22.5	7.9	7.9	6.7	6.7	10.7	10.7	23.3	23.3
Antecedent moisture (percent)	3.2	20.8	11.9	19.3	6.9	21.9	6.7	26.4	8.4	21.4	8.2	----
Clay (percent)	17	17	22	22	22	22	22	22	21	21	18	18
Root concentration (grams/decimeter^3)	6.22	6.22	6.70	6.70	5.28	5.28	8.56	8.56	10.84	10.84	9.12	9.12
Bare soil and rock (percent)	16	16	8	8	21	21	5	5	20	20	4	4
Precipitation (inches)	1.50	1.70	1.47	1.65	1.72	1.69	1.64	1.86	1.68	1.82	1.47	1.02
Runoff (inches)	0	.04	.26	.42	.04	.25	.13	.22	.24	.65	.28	.49
Sediment yield (pounds)	0	.15	.33	.59	.15	.91	.30	.67	2.52	4.84	0	.01
(tons per square mile)	0	1.08	3.47	6.20	.99	6.01	2.02	4.51	16.30	31.31	0	1.09

4. Area—Obtained from a topographic survey of the site. Expressed in square feet.

5. Weighted mean slope—Obtained by measuring the area between contours and weighting the slope of that area according to the percentage the area is of the whole.

6. Antecedent moisture—Obtained from gravimetric samples of soil. Samples were taken at six locations within the site and averaged for the final result. Expressed as percentage by weight. Two runs are normally made at each site. The first in a dry condition and again after the water in the soil has come to gravimetric equilibrium. Soil-moisture samples were taken before each run.

7. Clay—Obtained from soil samples taken from the top 10 centimeters of soil at numerous locations within the site. Samples were analyzed for percentage by weight of material less than 0.002 millimeters in diameter.

8. Root concentration—The amount of fibrous root material in the top 10 centimeters of soil. Expressed in grams per cubic decimeter of soil.

9. Bare soil and rock—Obtained from three 20-foot transects within each site using a point frame and the first point-contact method. Pins lowered to the vegetation or ground surface are recorded as first encountering aerial vegetation, mulch, bare soil, or rock. Expressed as hits per 100 pins.

Precipitation

Precipitation events of various recurrence intervals, duration, and magnitude for the Prairie Dog Creek area were obtained from National Oceanic and Atmospheric Administration (NOAA) Atlas 2, Volume 1, for Montana. Estimated runoff for these events were computed using infiltration rates obtained from the simulation runs. These data are shown in table 2.

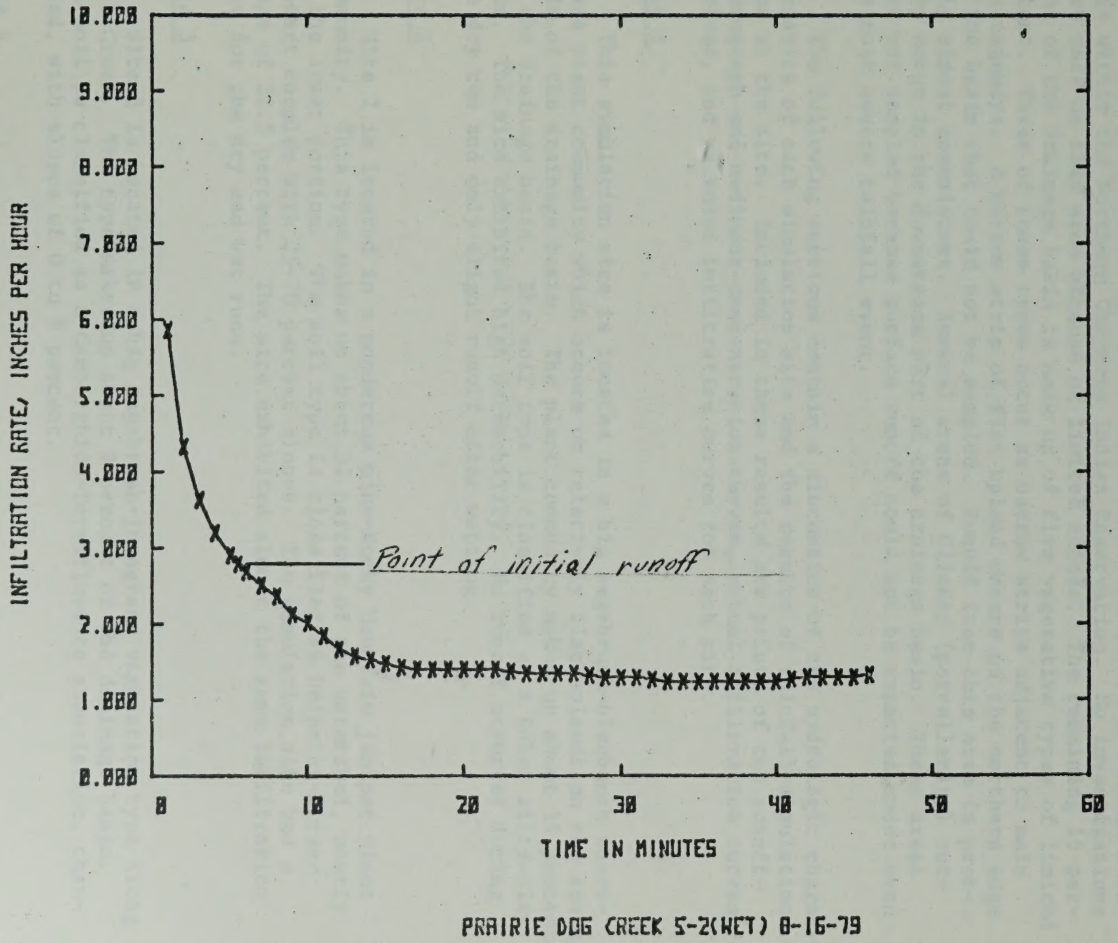
The infiltration rate of the soil during the early part of the run usually exceeds the application rate of rainfall. In order to determine runoff values from natural rainstorms exceeding this rate, it was necessary to estimate the early part of the infiltration curve. This was done by extending the infiltration curve backward in time from the point of initial runoff using a power function based on several defined curves and the theory that initial infiltration rate is infinite. The results of one of these computations is shown in figure 1.

No runoff occurred during the dry run at site 1 and, therefore, the infiltration curve could not be defined. Infiltration exceeded the application rate of 2.34 inches per hour during the entire run.

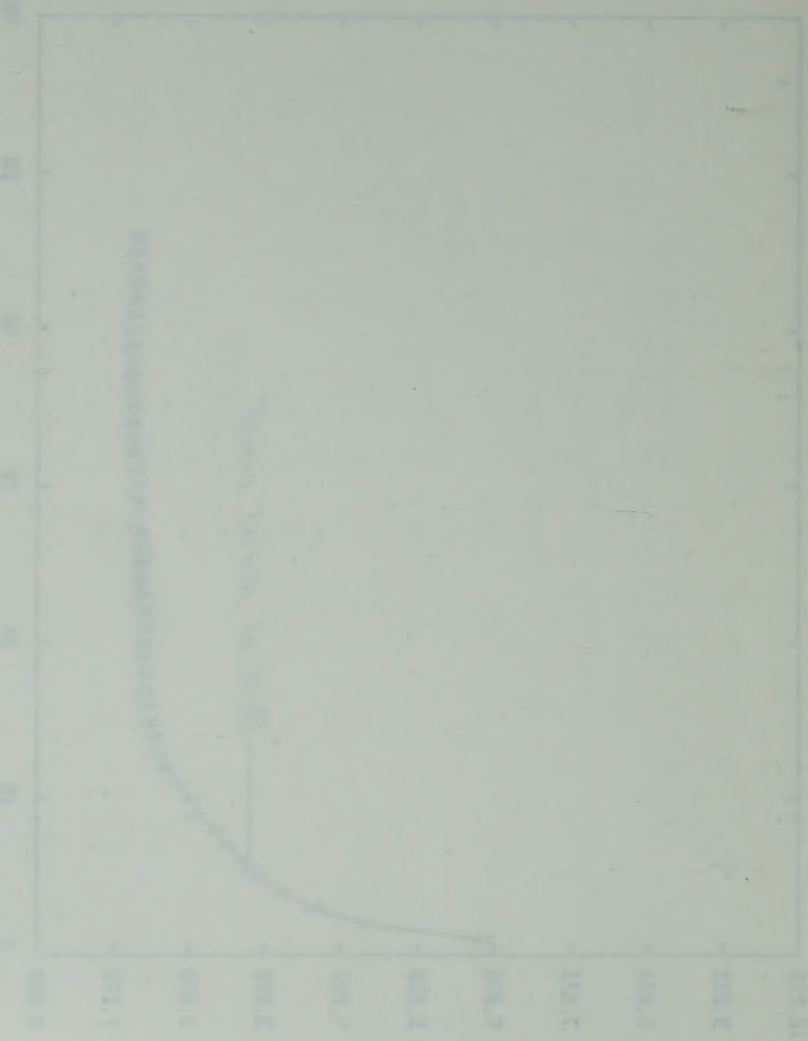
Table 2.--*Estimated runoff, in inches, from storms of designated frequency, duration, and magnitude*

(Precipitation values from NOAA Atlas 2, Vol. 1, Montana)

Recurrence interval (years)	Magnitude (inches)	Simulation site										
		1-wet	2-dry	2-wet	3-dry	3-wet	4-dry	4-wet	5-dry	5-wet	6-dry	6-wet
						30-minute duration						
2	.53	0	0	0	0	0	0	0	0	0	0	.15
5	.71	0	0	0	0	0	0	0	0	.02	.06	.30
10	.87	0	.07	.09	0	0	0	0	.01	.12	.16	.44
25	1.03	0	.20	.22	.04	.08	0	.01	.09	.23	.28	.59
50	1.18	.05	.34	.34	.13	.18	.10	.10	.20	.36	.41	.74
100	1.44	.20	.58	.58	.33	.41	.30	.29	.41	.58	.65	.99
						60-minute duration						
2	.67	0	0	0	0	0	0	0	0	0	0	.05
5	.90	0	0	0	0	0	0	0	0	0	0	.24
10	1.10	0	0	0	0	0	0	0	0	0	0	.41
25	1.30	0	0	0	0	0	0	0	0	.01	.10	.59
50	1.50	0	0	.02	0	0	0	0	0	.14	.25	.77
100	1.82	0	.21	.23	.02	.15	0	0	.02	.41	.51	1.08



PRAIRIE DOG CREEK S-2(WET) 8-16-79



Vegetative types

As stated previously, rainfall-simulation runs were made at six different sites within the Prairie Dog Creek basin. These runs were made in six different vegetative types which comprise about 76 percent of the area of Prairie Dog Creek. About 8 percent of the drainage basin lies within the Northern Cheyenne Indian Reservation. No investigations were made on this area because of limited access. The remaining 16 percent of the drainage basin is made up of five vegetative types of limited extent. Three of these types occur as narrow strips adjacent to main drainageways. A narrow strip of flat upland occurs on the northern edge of the basin that could not be sampled. Runoff from this area is probably almost nonexistent. Several areas of Clinker (porcellanite) outcrop occur in the downstream part of the drainage basin. These areas were not sampled because surface runoff could not be expected under even the most severe rainfall event.

The following sections contain a discussion of the hydrologic characteristics of each simulation site and the results of rainfall-simulation runs at the site. Included in these results are prints of the runoff-hydrograph and sediment-concentration curves, actual infiltration curves derived, and extended infiltration curves for each site.

Site 1

This simulation site is located in a big sagebrush-bluebunch wheatgrass plant community which occurs on relatively flat uplands on the south side of the drainage basin. The plant community makes up about 14 percent of the drainage basin. The soil type is classified as a Kobar silty-clay loam. The site exhibited high permeability. No runoff occurred during the dry run and only slight runoff after wetting.

Site 2

Site 2 is located in a ponderosa pine-Rocky Mountain juniper plant community. This type makes up about 31 percent of the watershed, mostly in the lower portion. The soil type is classified as Delpoint-Birney Cabbart complex with 25-70 percent slopes. The simulation site had a slope of 22.5 percent. The site exhibited almost the same infiltration rate for the dry and wet runs.

Site 3

Site 3 is located in a big sagebrush-junegrass vegetation type along Jack Creek. The type makes up about 9 percent of the drainage basin. The soil is classified as a Camborthids-Torrifluvents association, channeled, with slopes of 0 to 8 percent.

Site 4

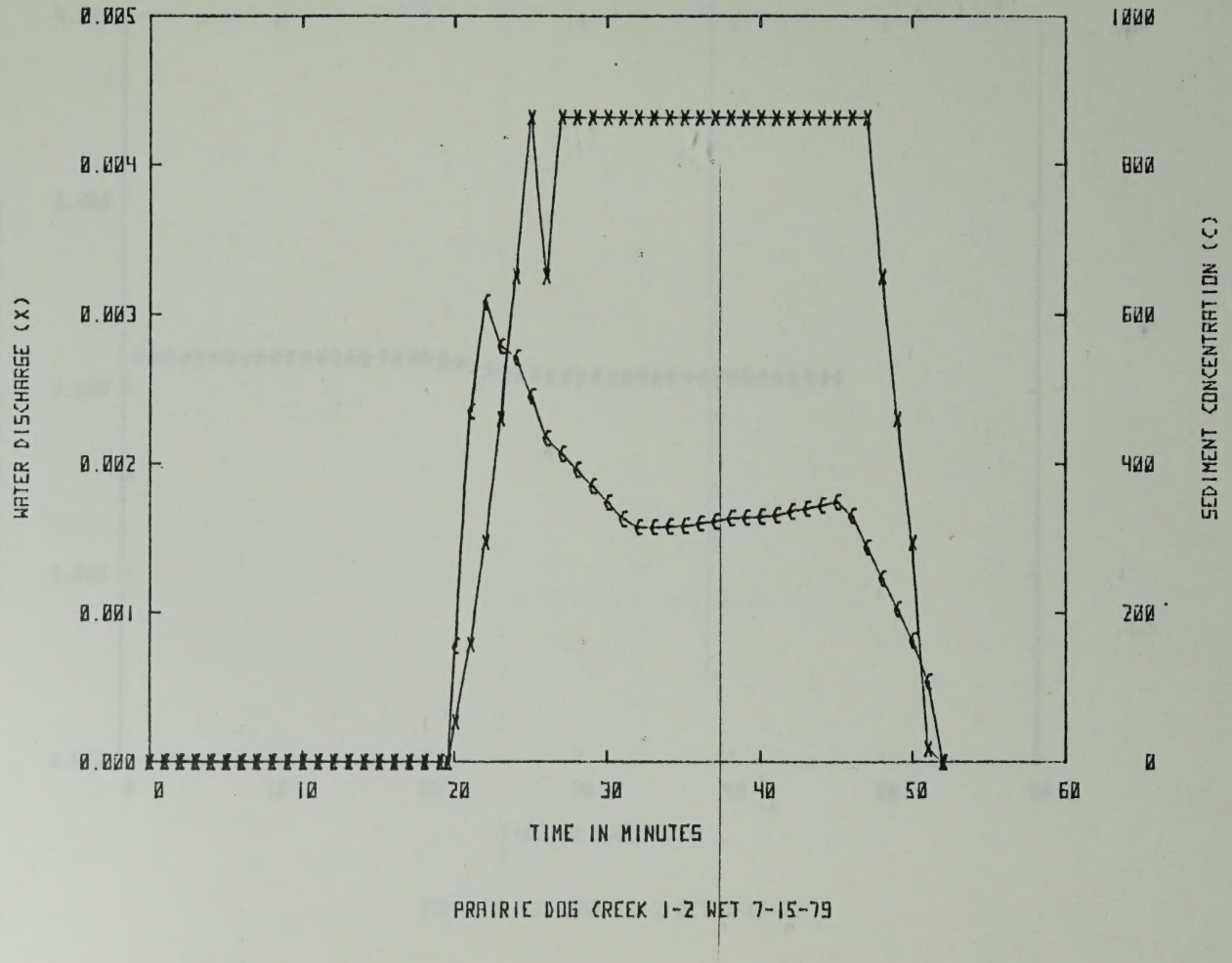
Site 4 is located in a silver sagebrush-green needlegrass plant community along the middle reaches of the main Prairie Dog Creek channel. The plant community occurs on alluvium above the present flood plain and occupies about 9 percent of the drainage basin. The soil is classified as a Thedalund-McCrae loam, dissected.

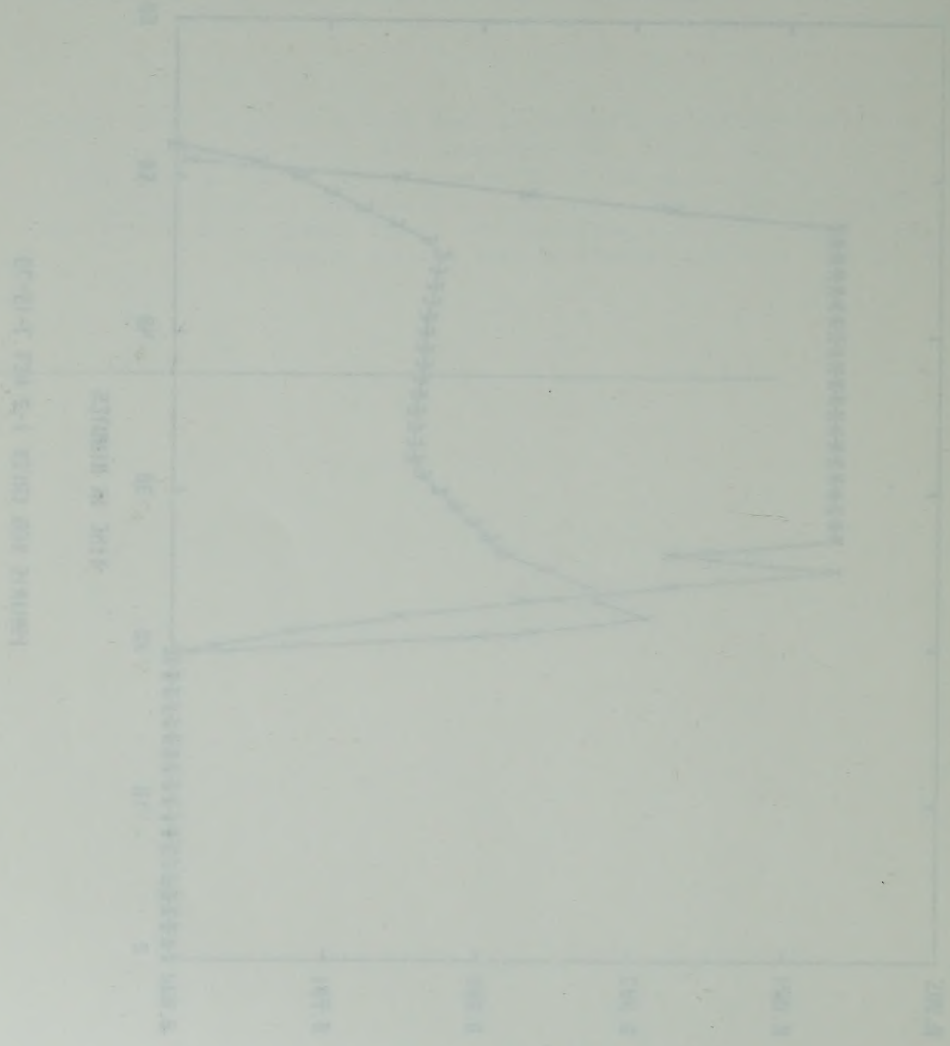
Site 5

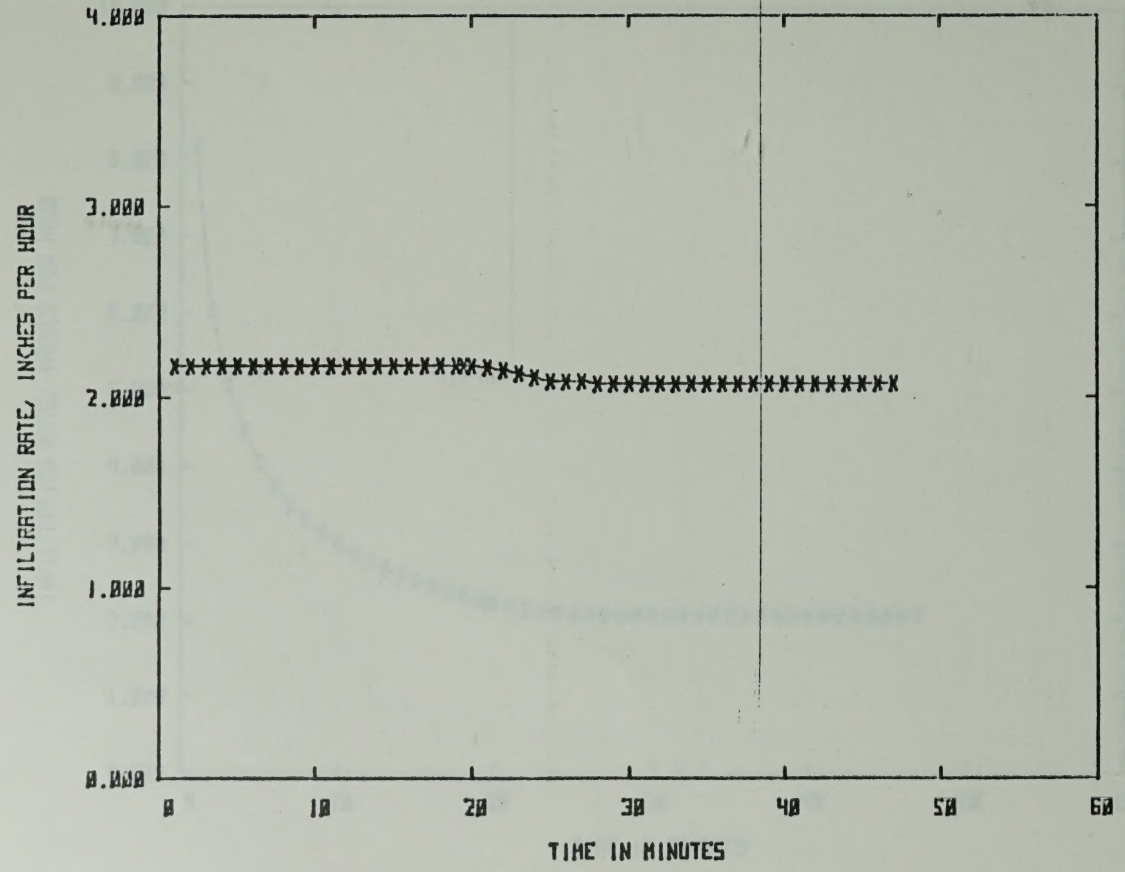
Site 5 is located on a big sagebrush-hairy chess plant community. This plant community also occurs on alluvium above the present flood plain and it occupies about 4 percent of the drainage basin. The soil is classified as Camborthids-Torrifluvents association, as was that at site 3.

Site 6

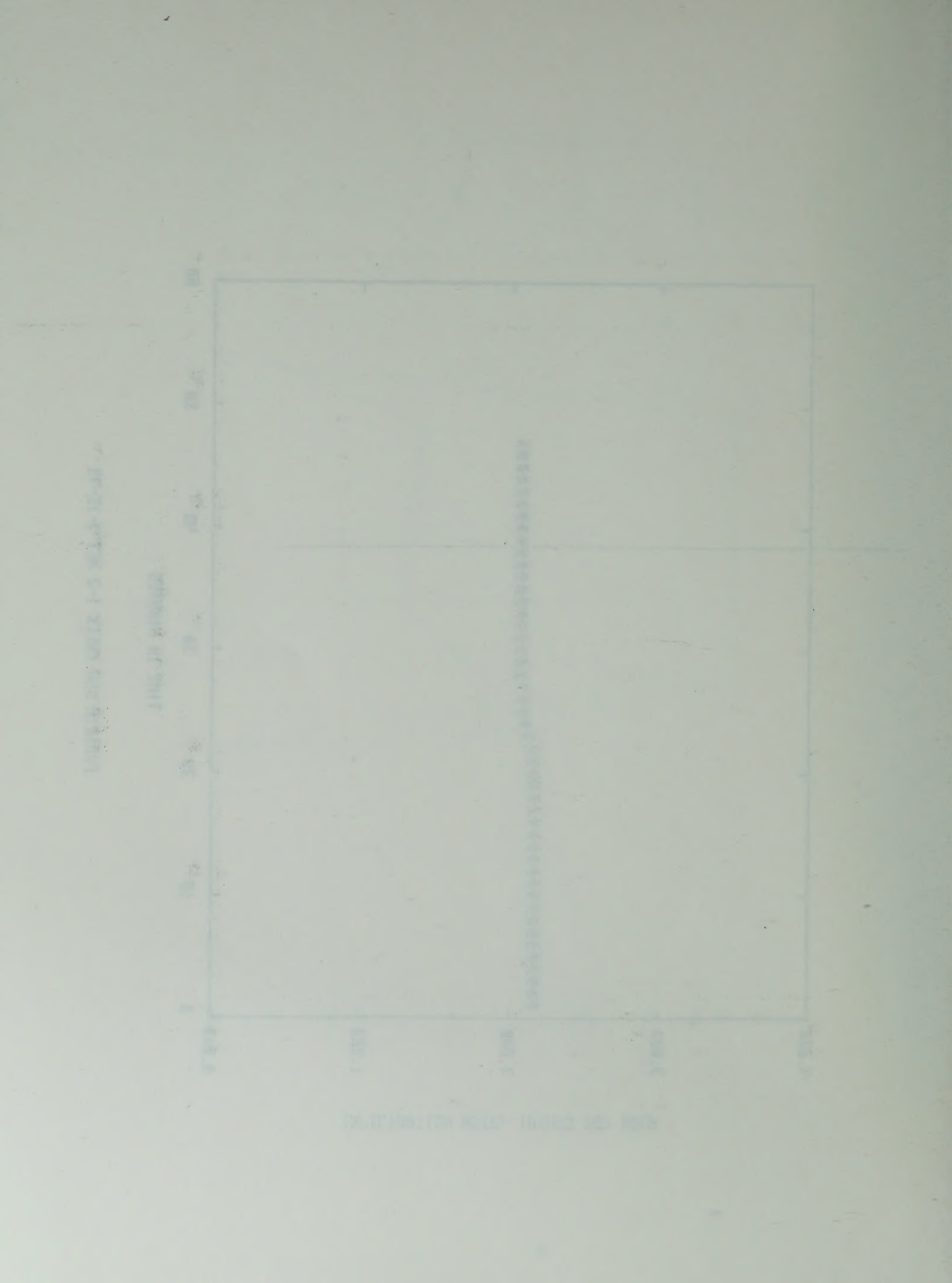
Site 6 is located on a ponderosa-pine site on a slope in the middle part of the drainage basin. The ponderosa-pine sites occupy about 9 percent of the drainage area and occur on steep rocky slopes in the upper part of the drainage basin. The soil is classified as Doney-Wayden Complex, hilly. This site exhibited the lowest infiltration rate of all sites studied, possibly because of very shallow topsoils.

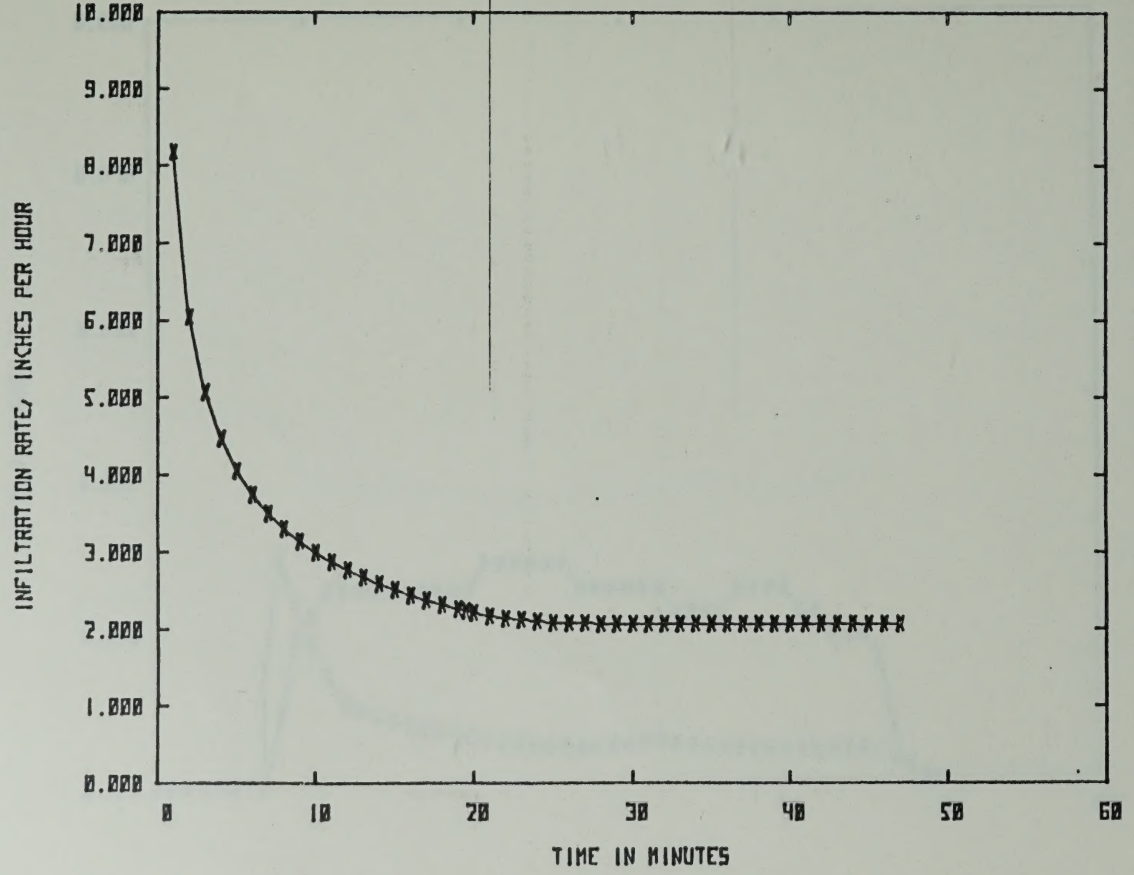

0.005
0.004
0.003
0.002
0.001
0.000
WATER DISCHARGE (X)
1000
800
600
400
200
0
SEDIMENT CONCENTRATION (C)
0
10
20
30
40
50
60
TIME IN MINUTES
PRAIRIE DOG CREEK 1-2 WET 7-15-79





PRAIRIE DOG CREEK 1-2 WET 7-15-79





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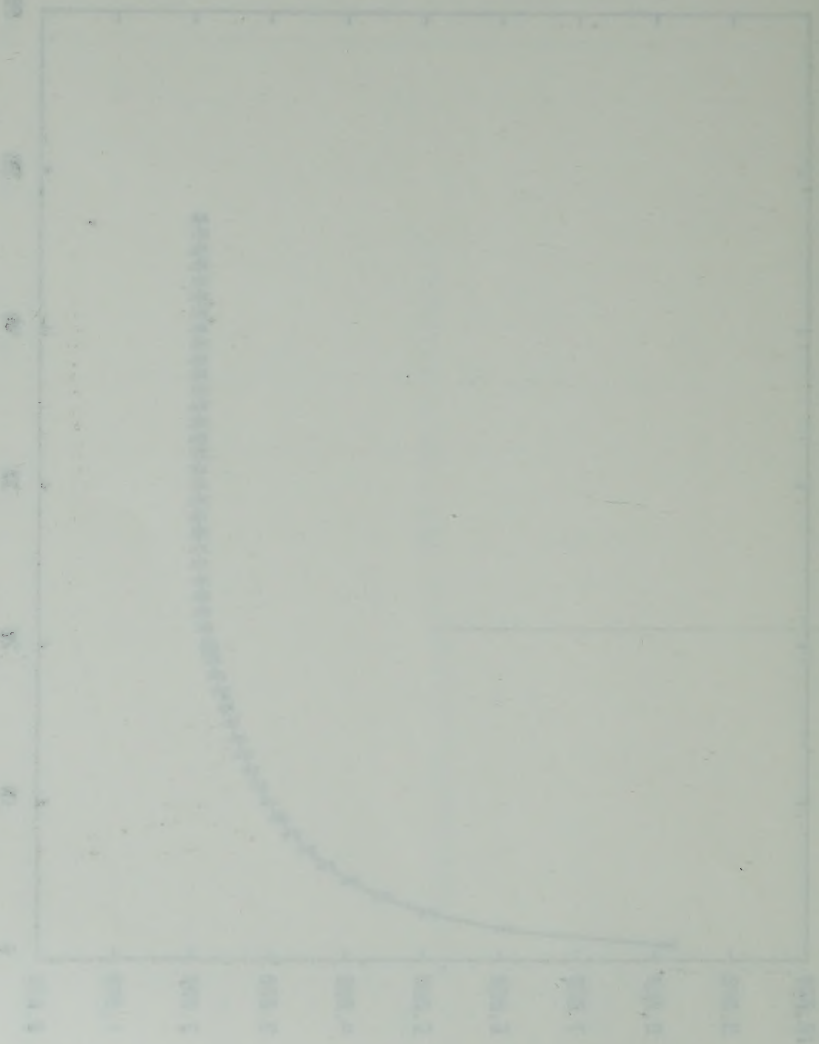

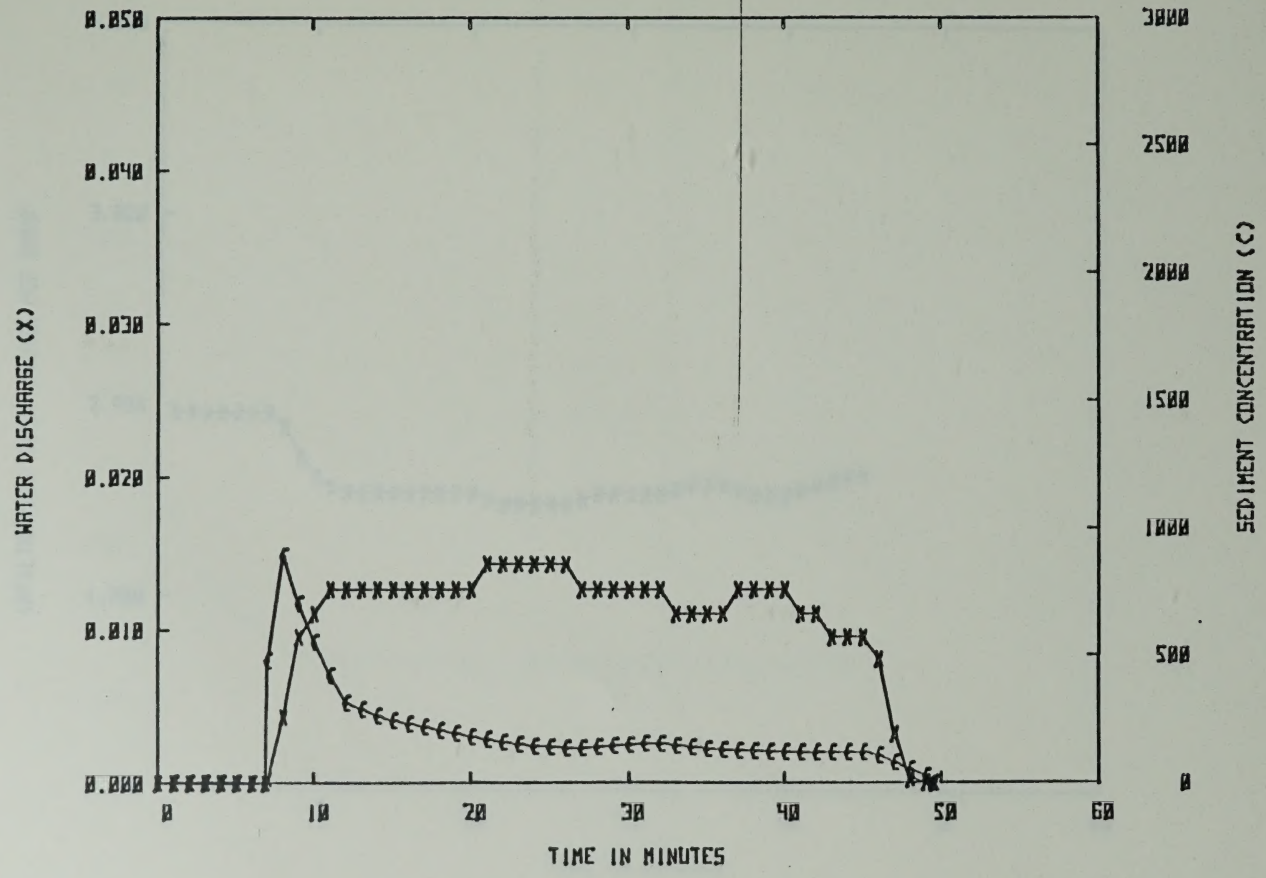

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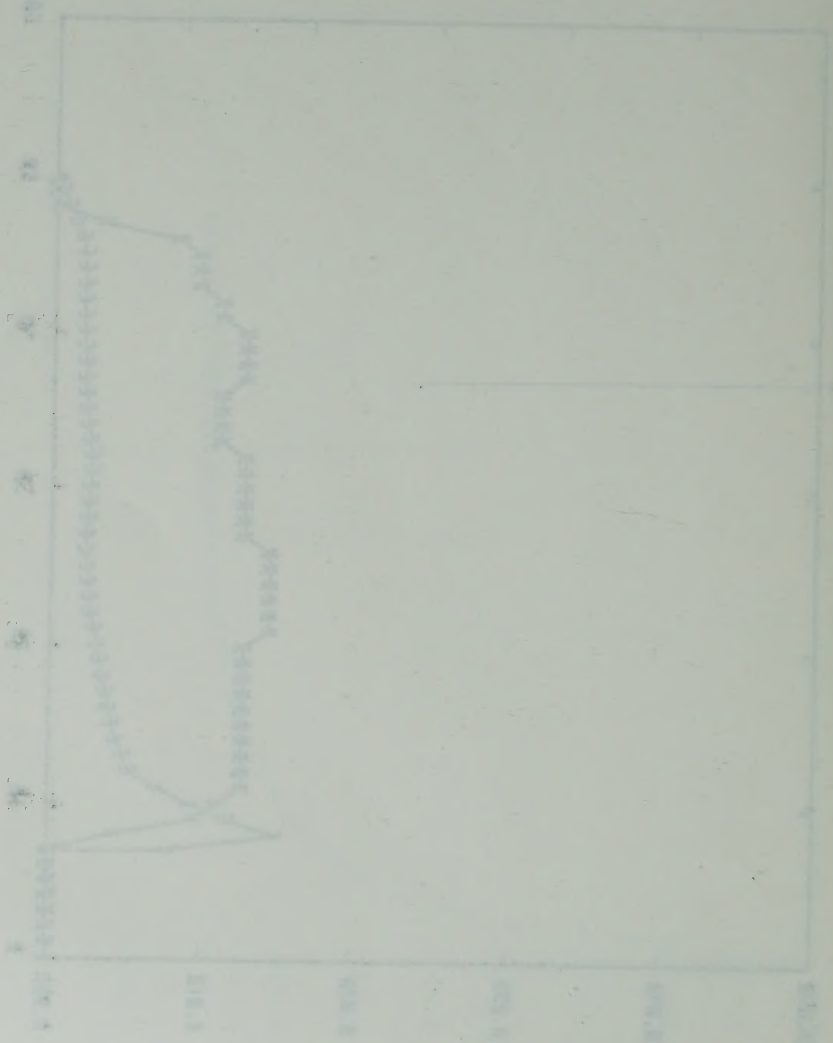

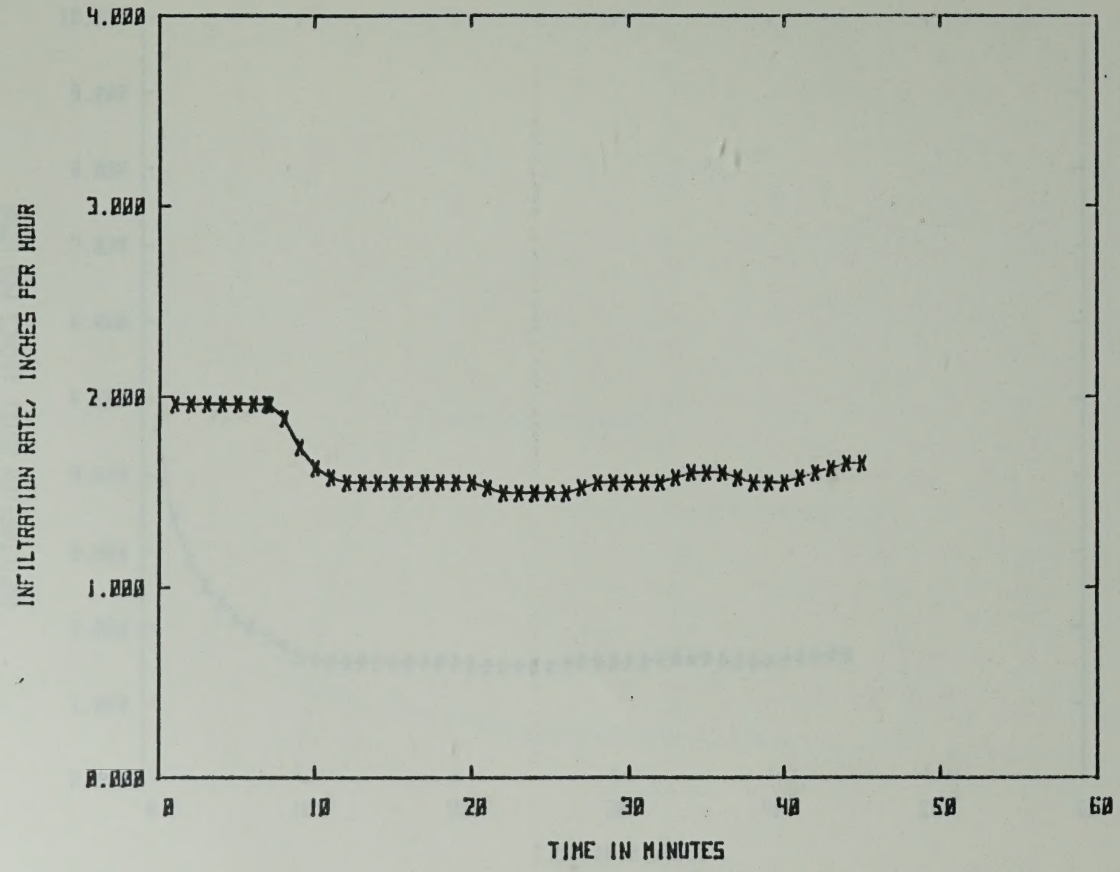

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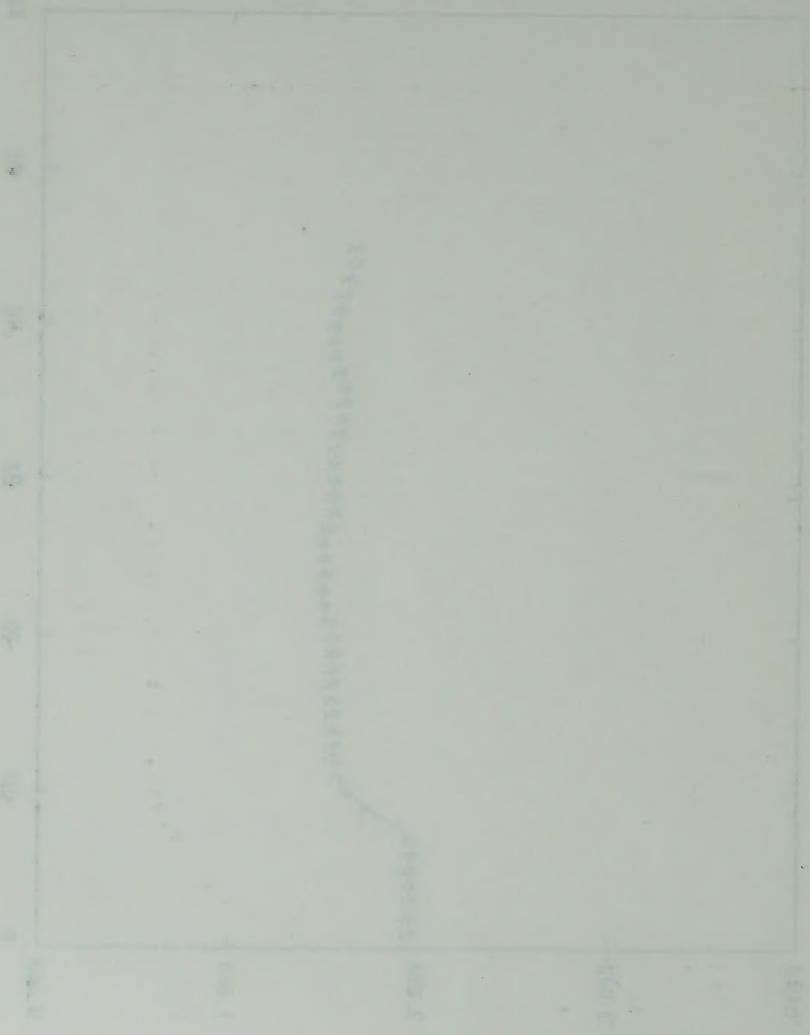

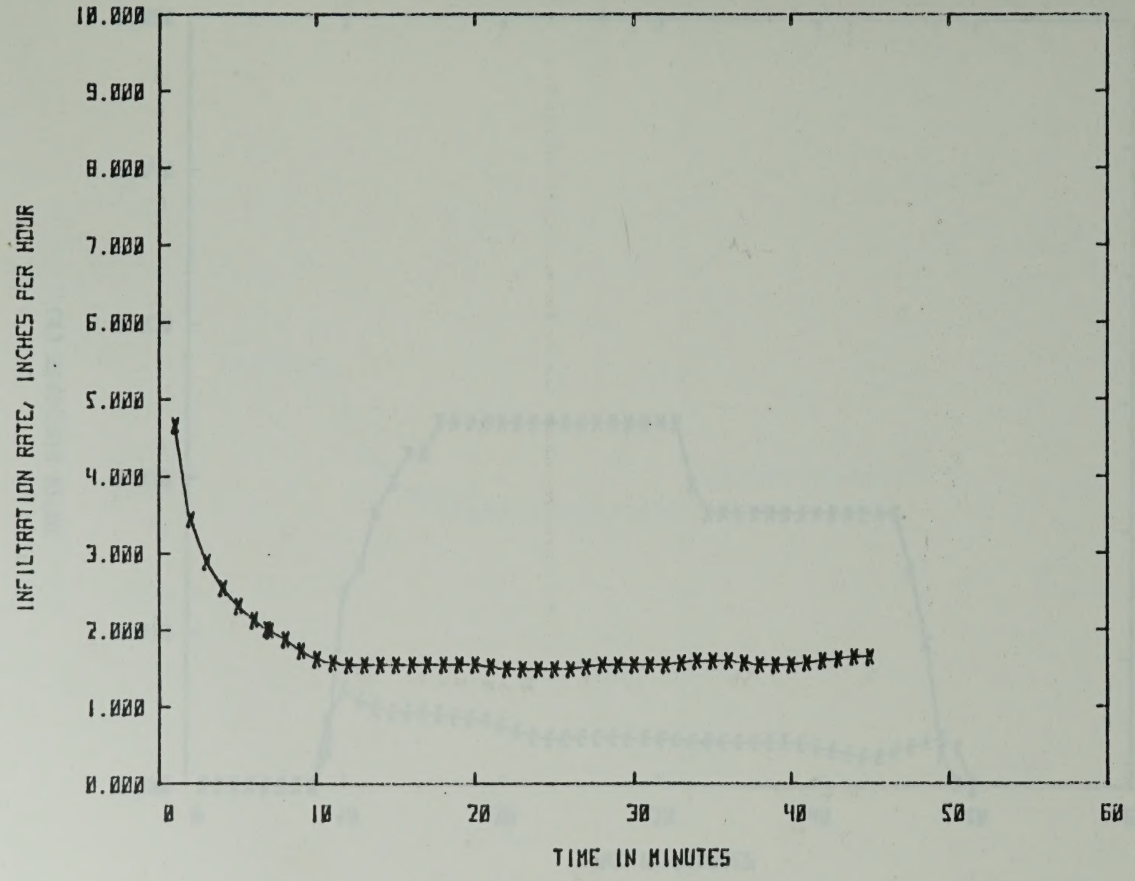

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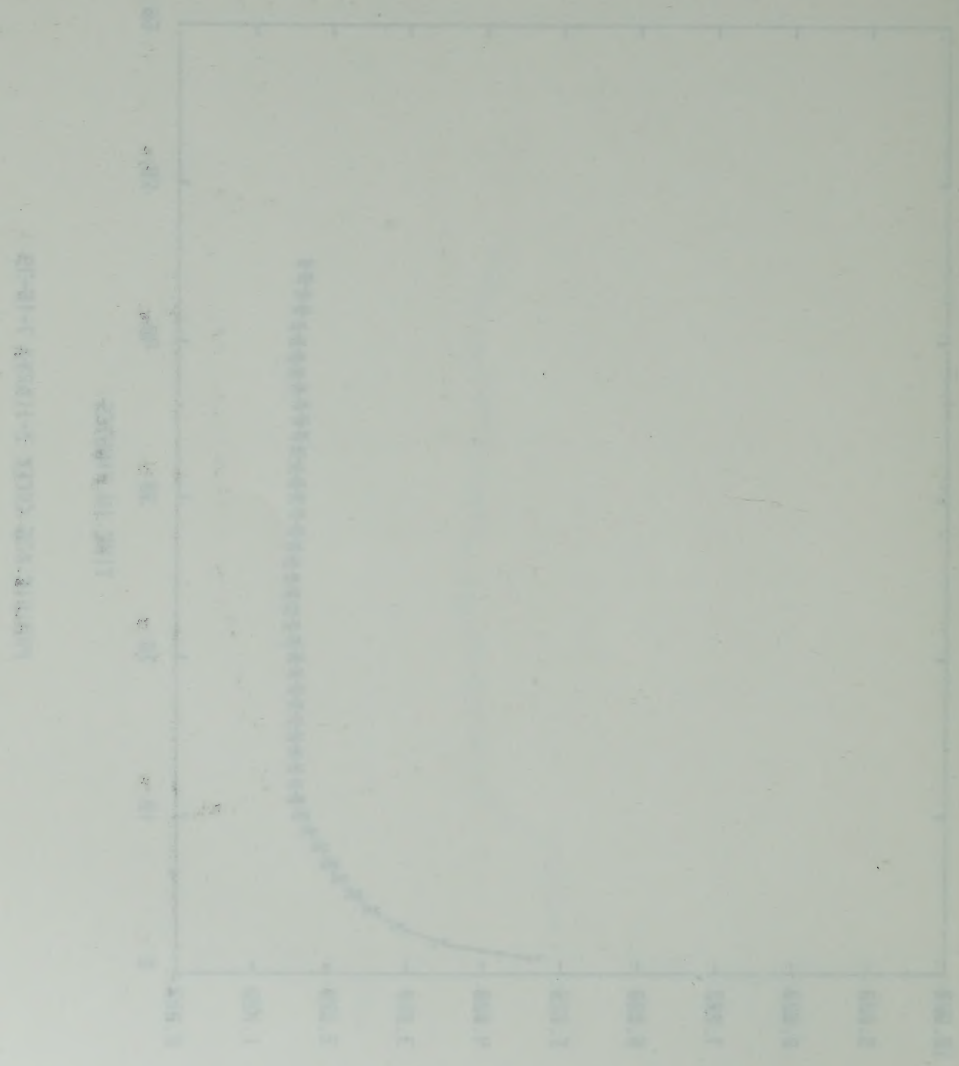

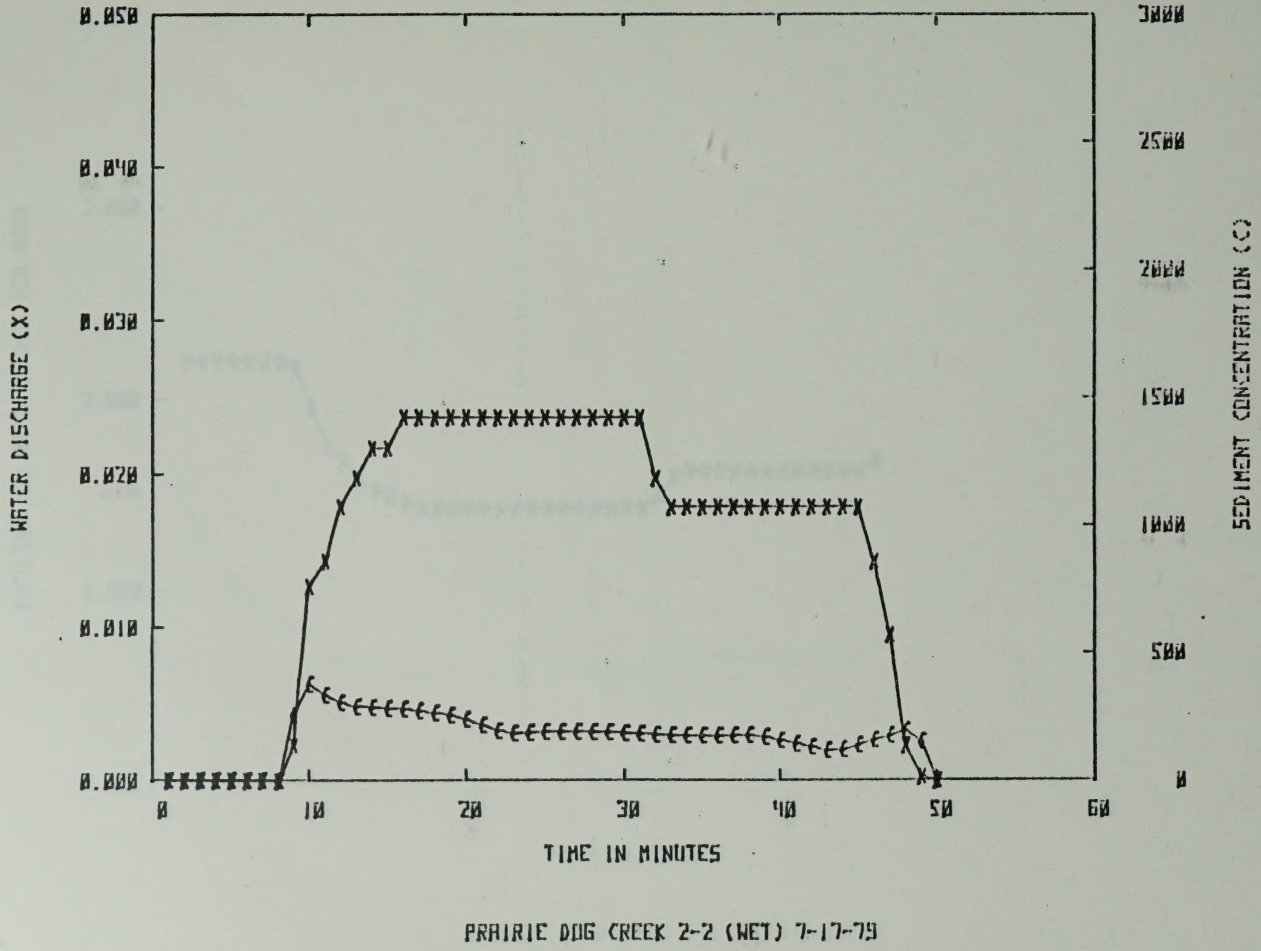

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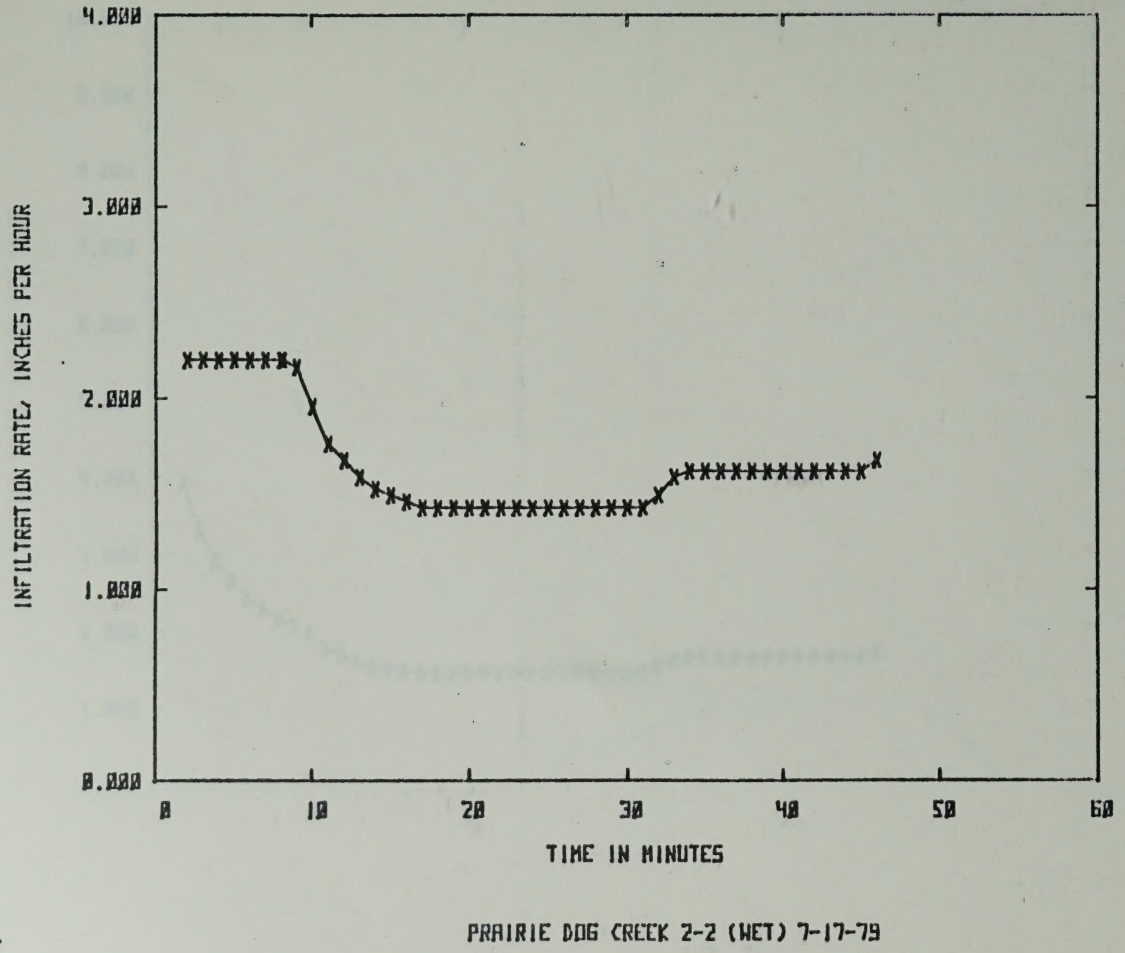

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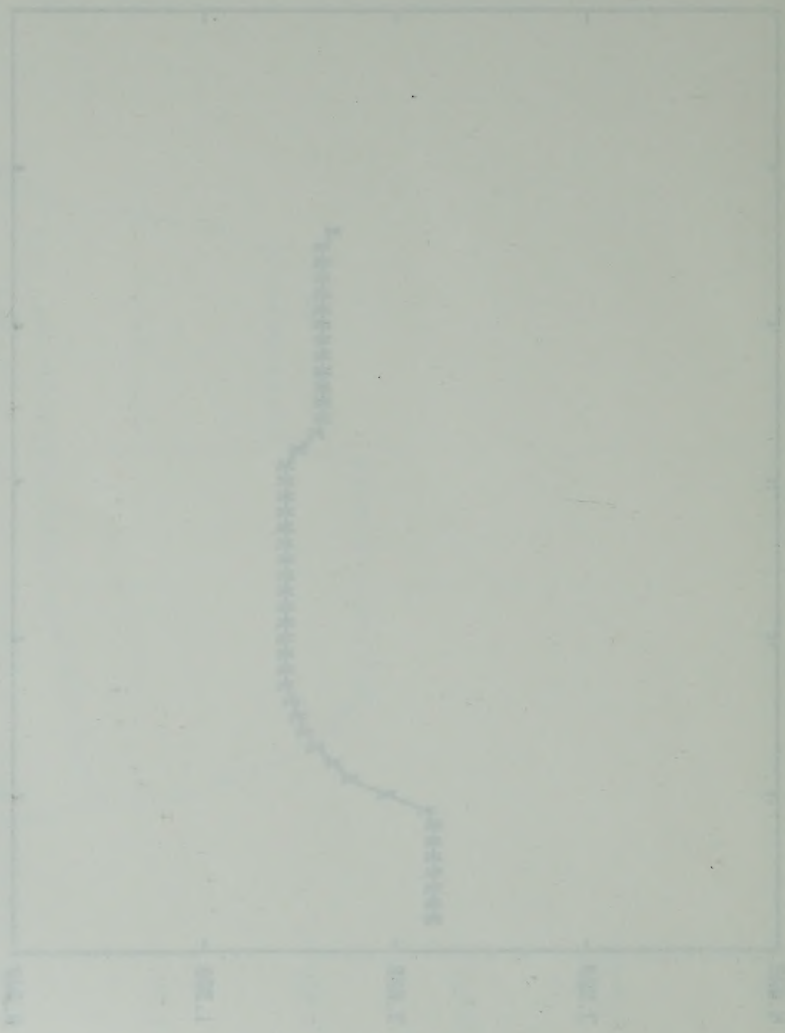

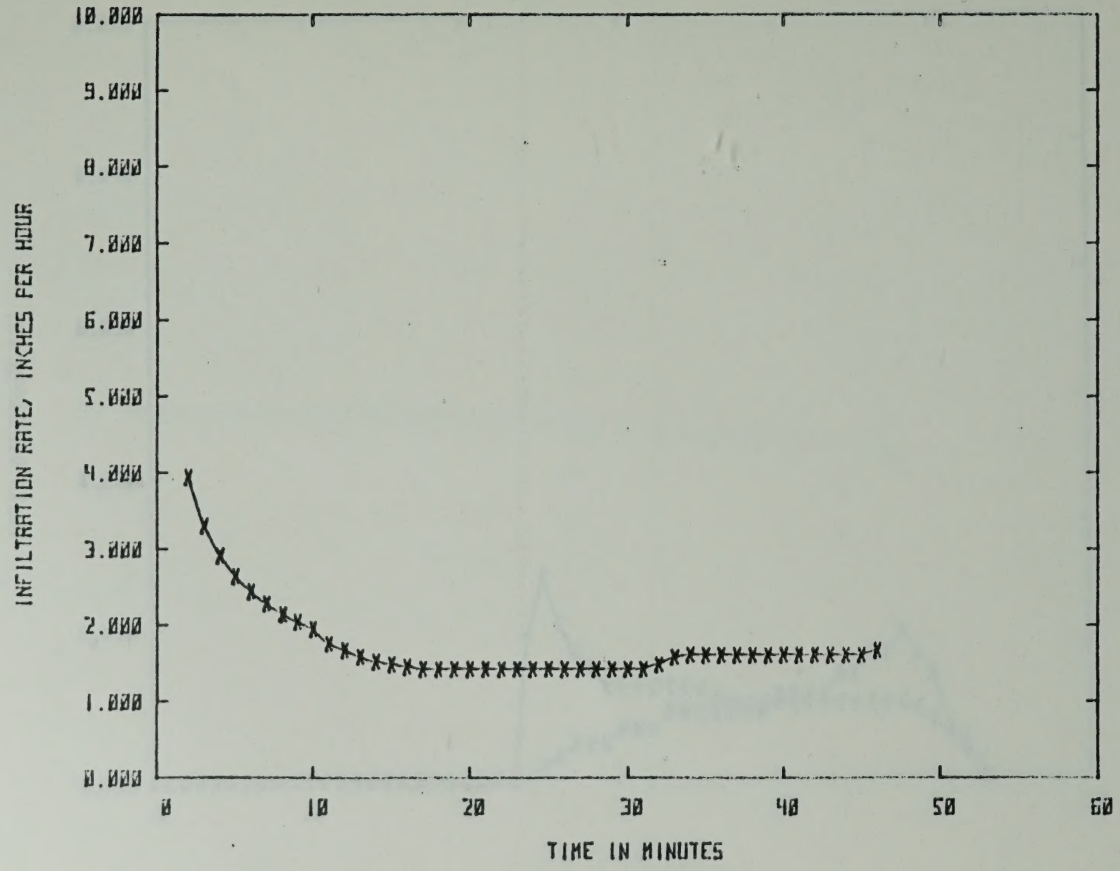

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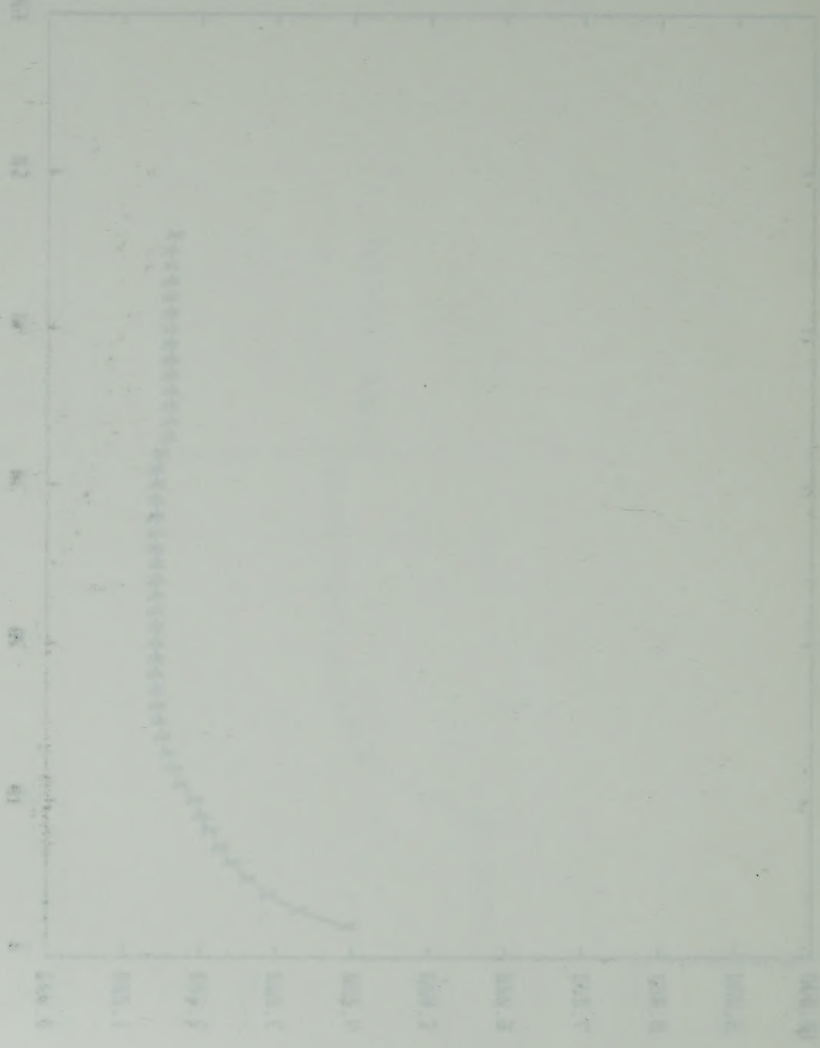
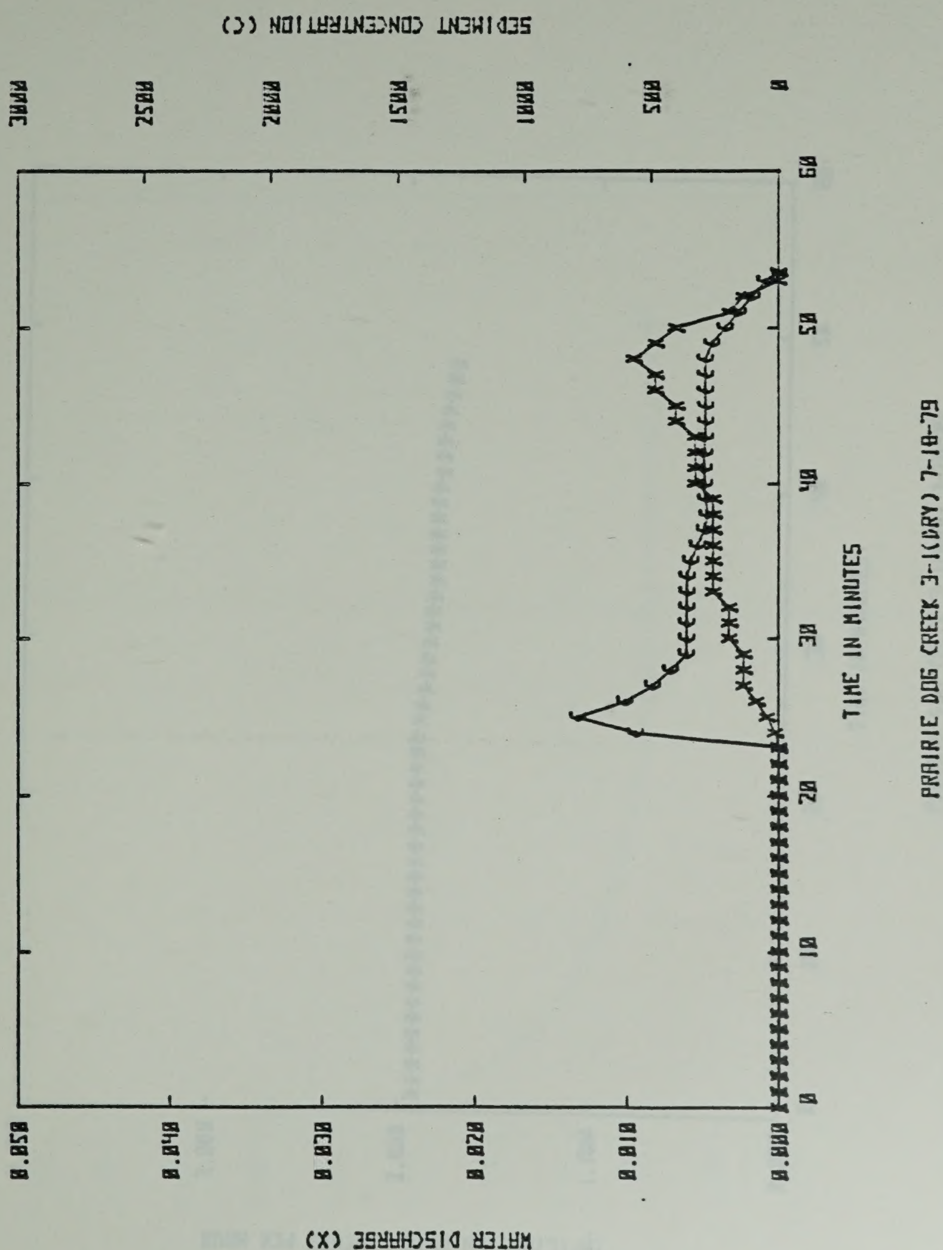
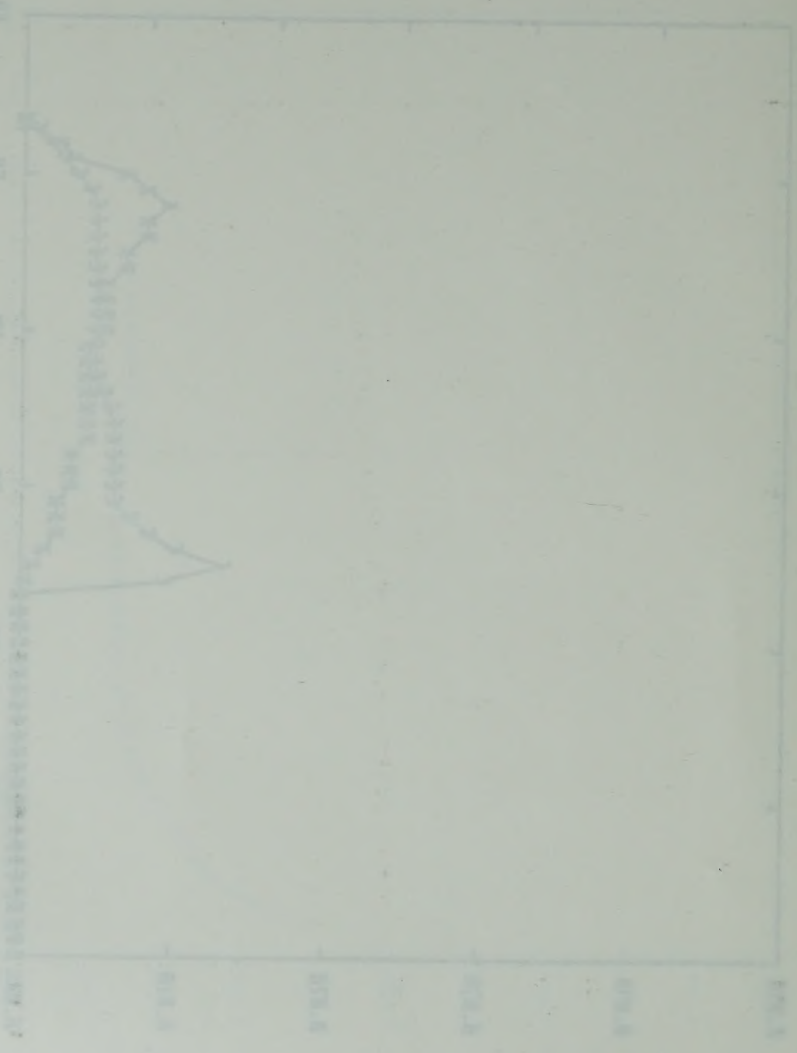
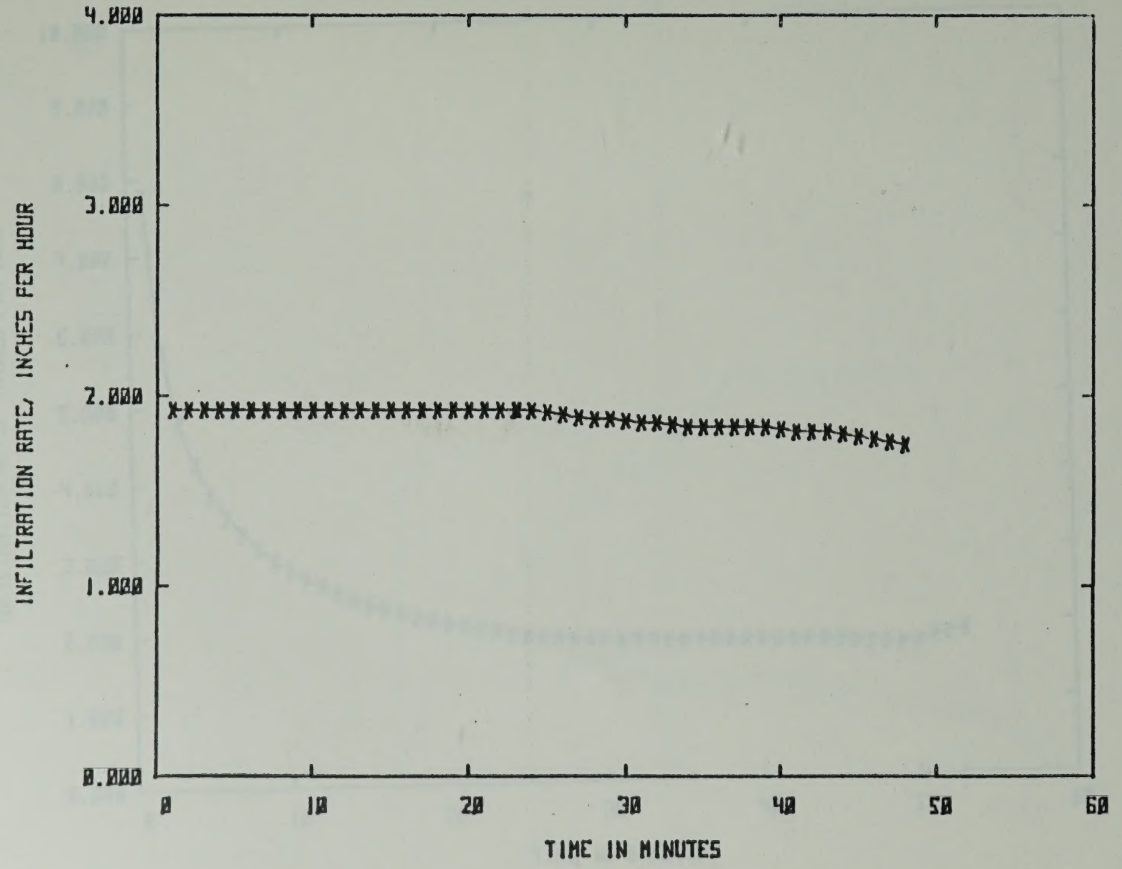



PRAIRIE DOG CREEK 3-1(DRY) 7-10-79
TIME IN MINUTES
WATER DISCHARGE (X)
SEDIMENT CONCENTRATION (C)
0.000
0.010
0.020
0.030
0.040
0.050
0
500
1000
1500
2000
2500
3000
0
10
20
30
40
50
60





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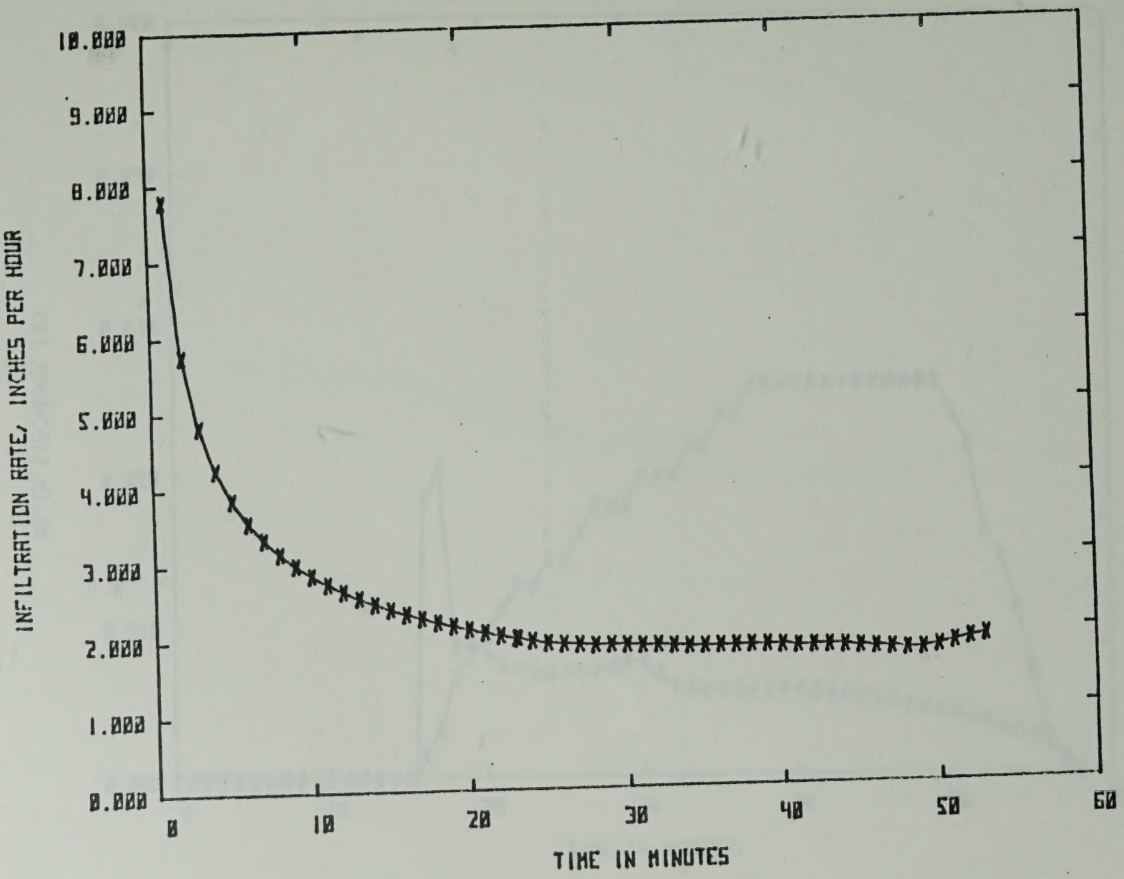

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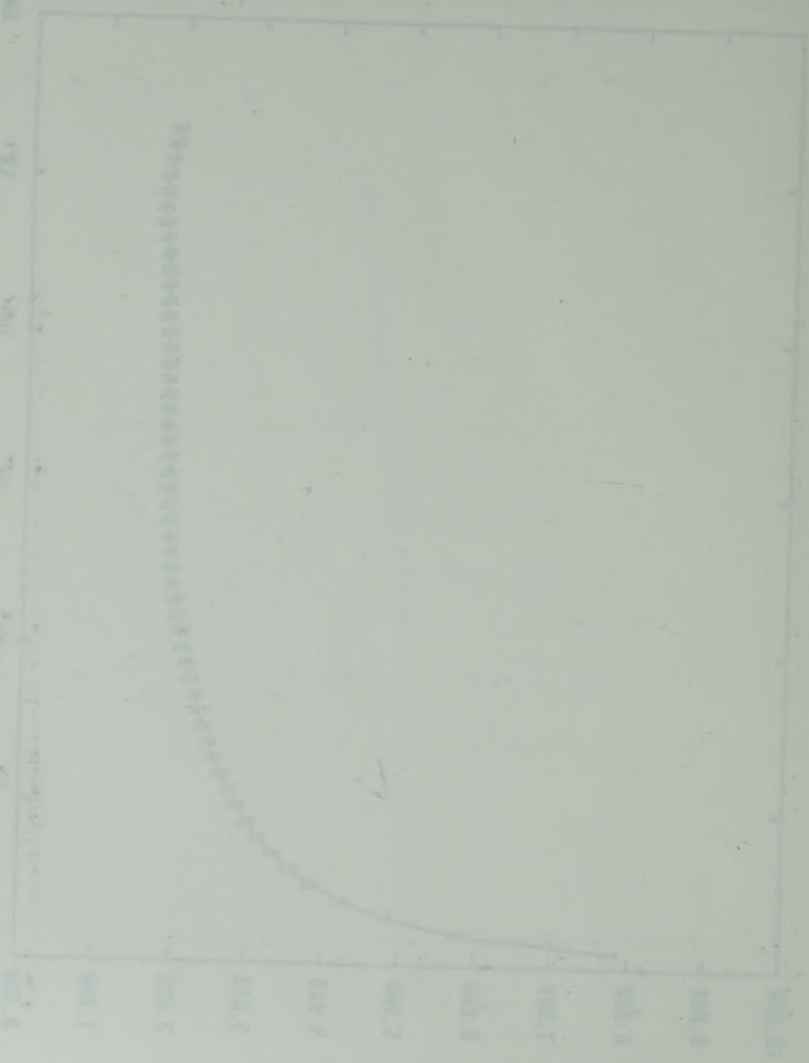

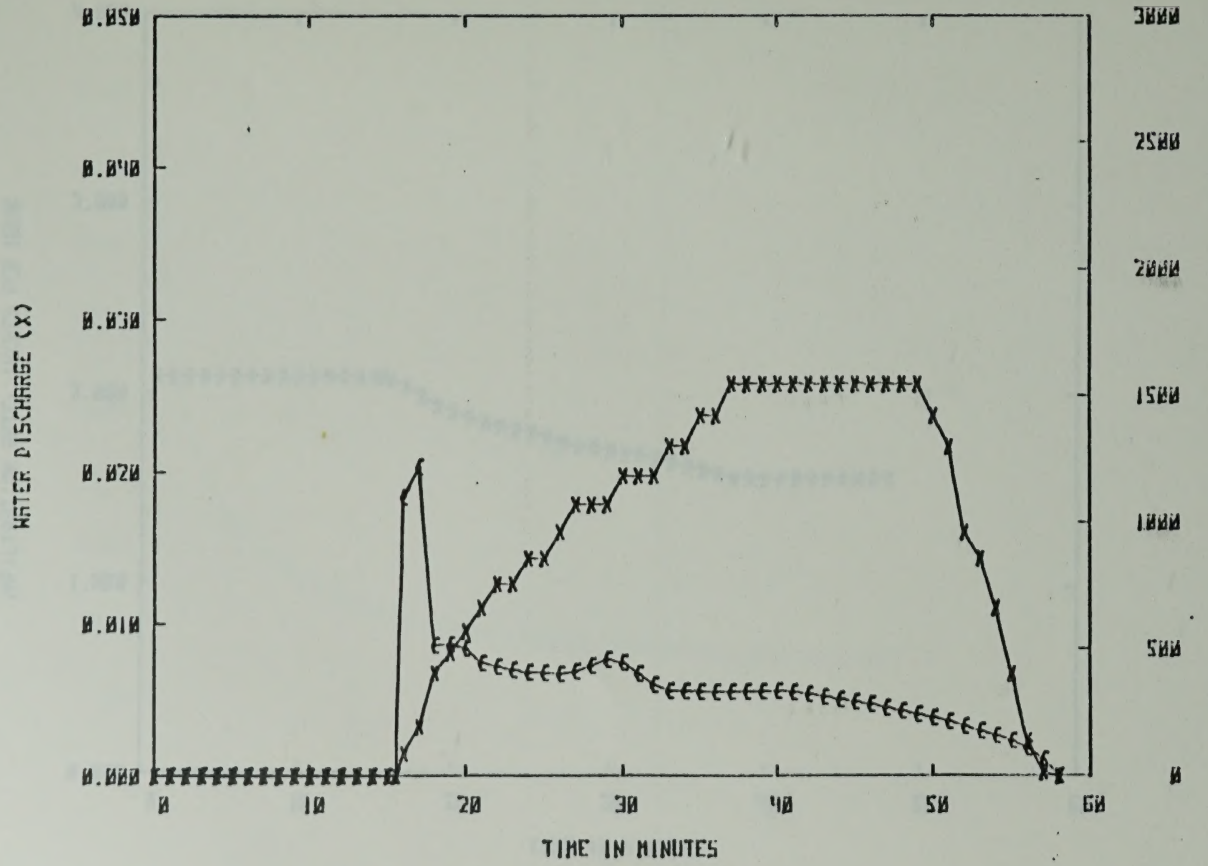

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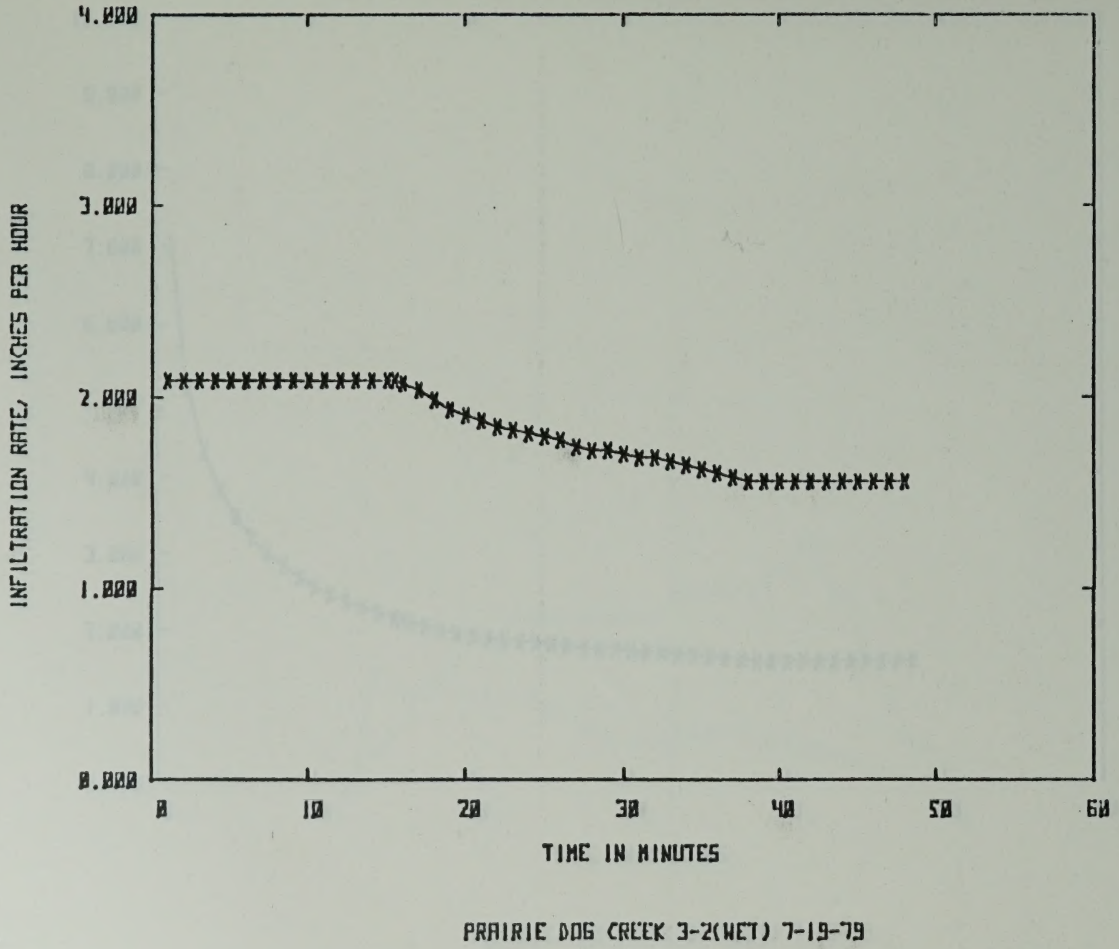

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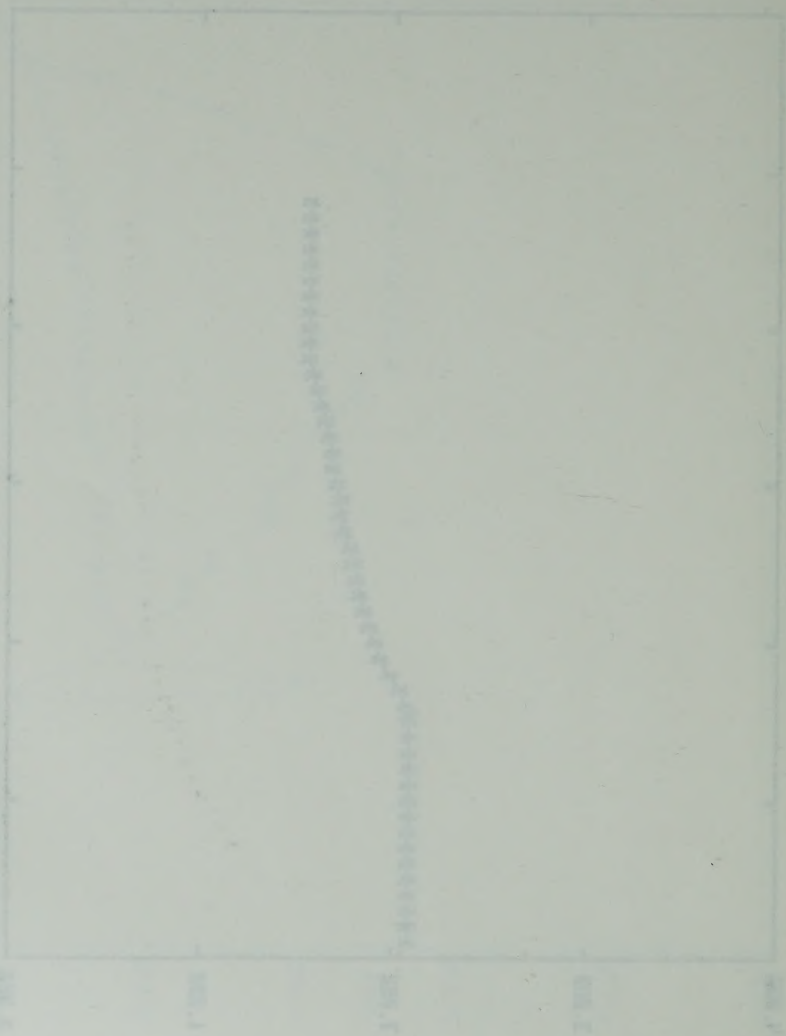

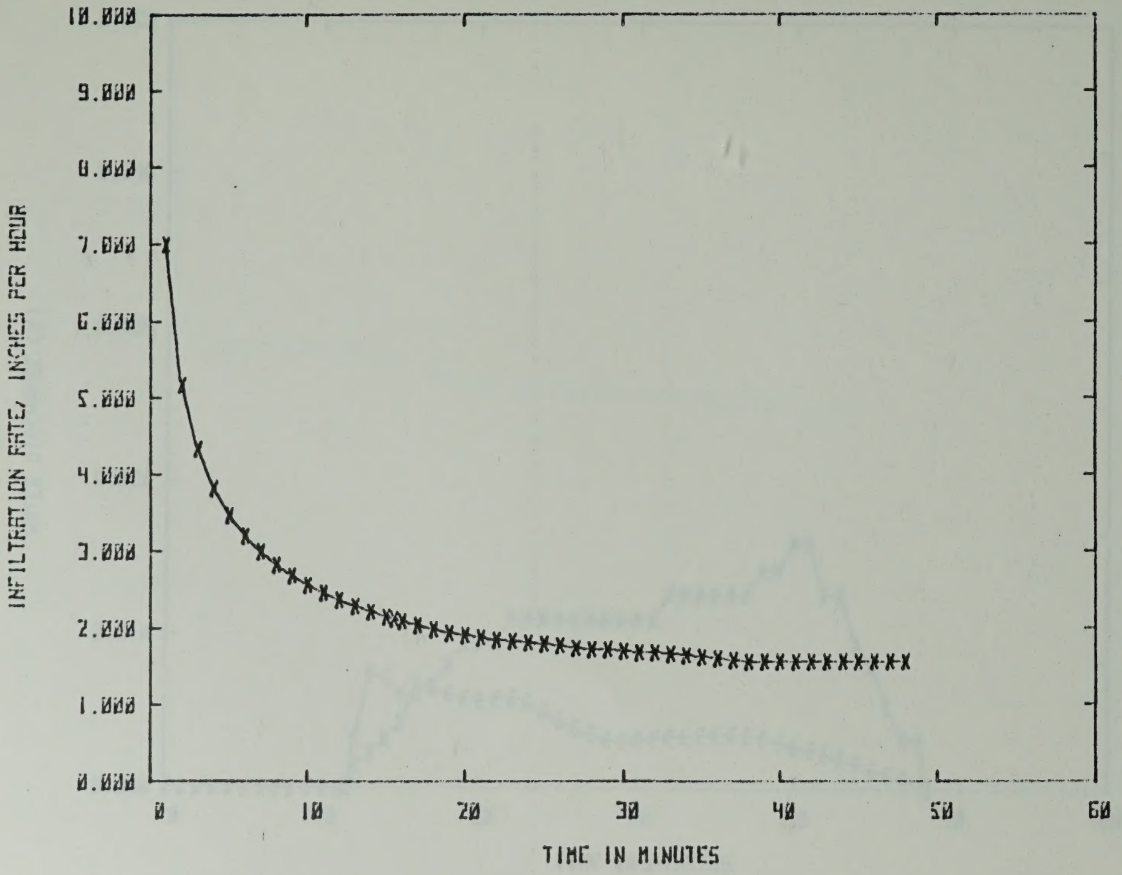

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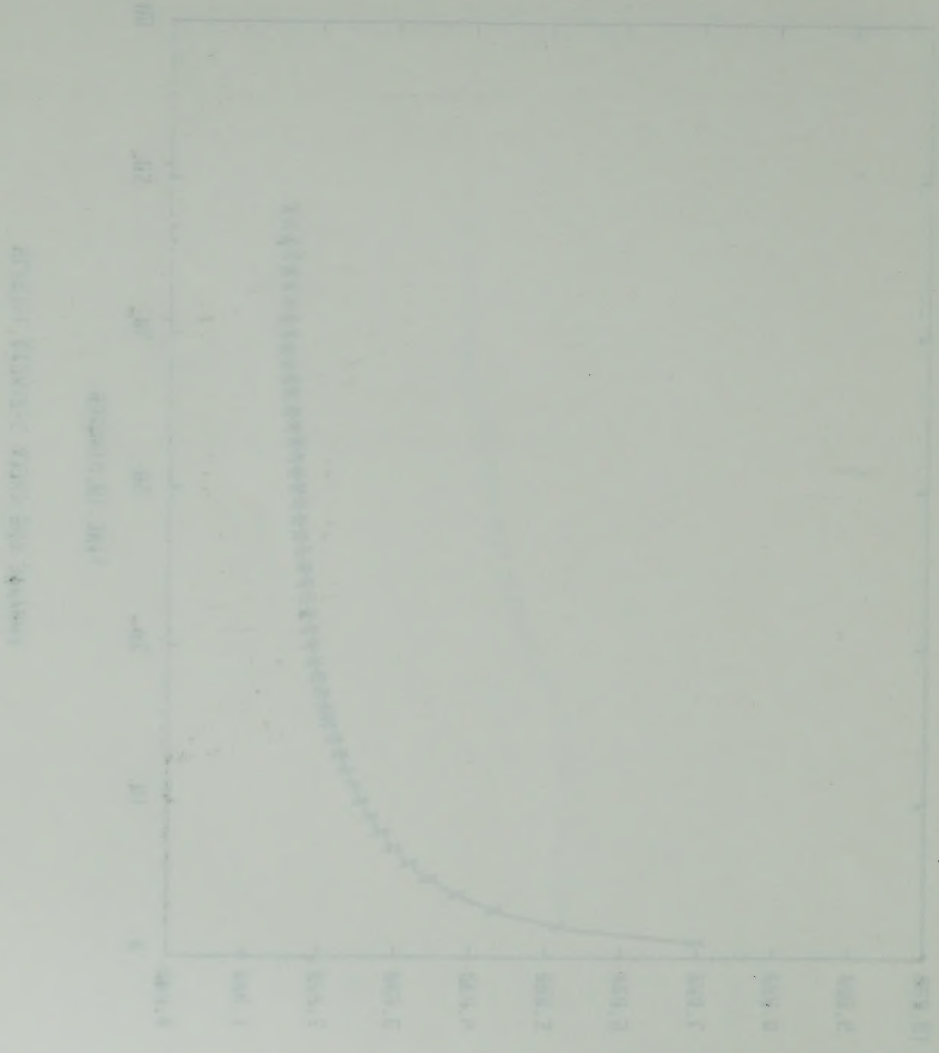
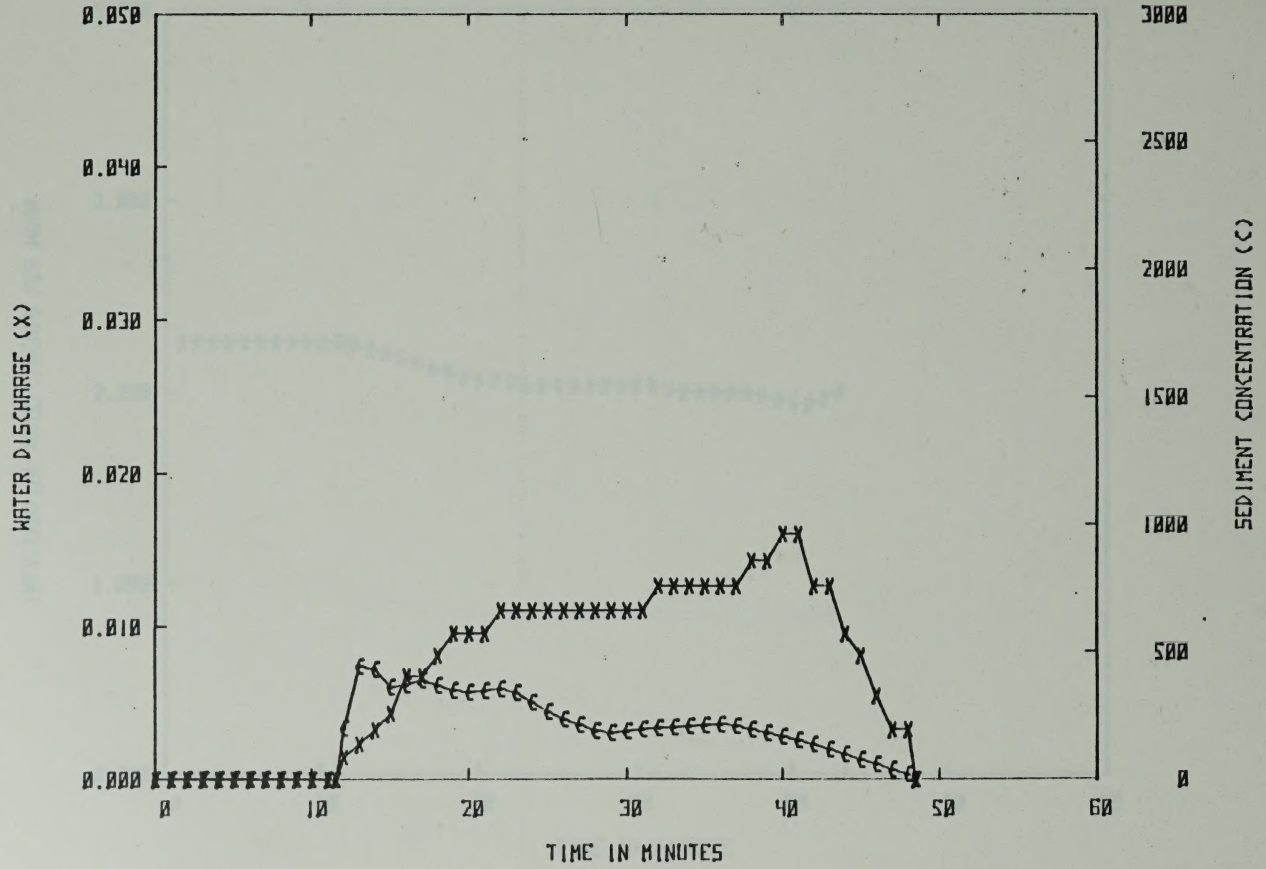
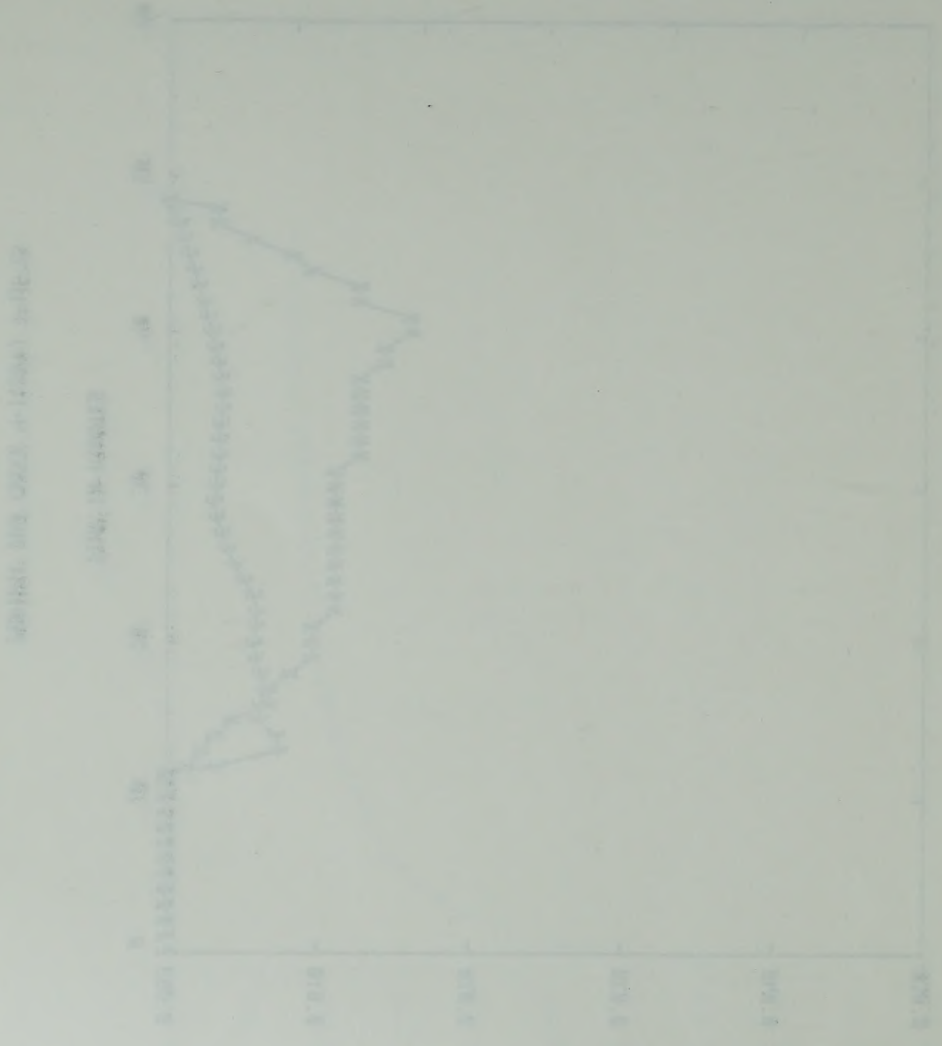
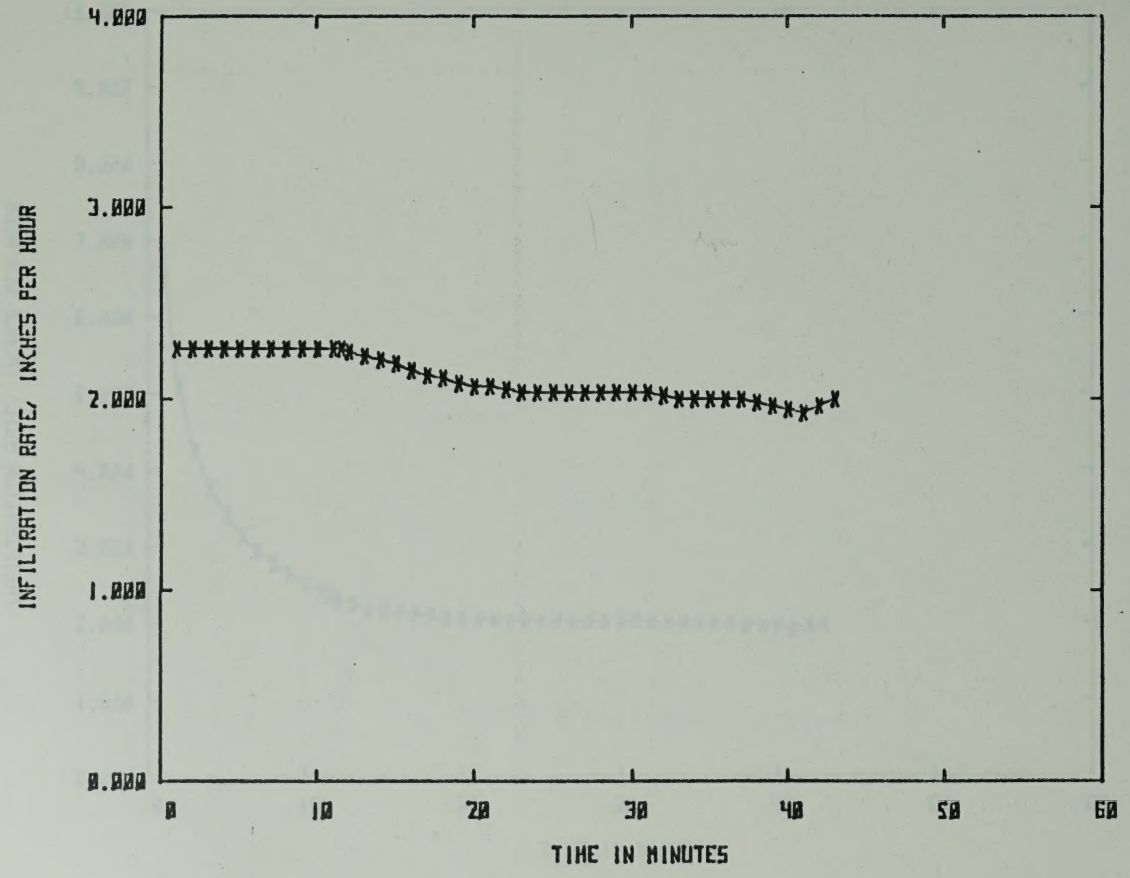




PRAIRIE DOG CREEK 4-1(DRY) 7-10-79





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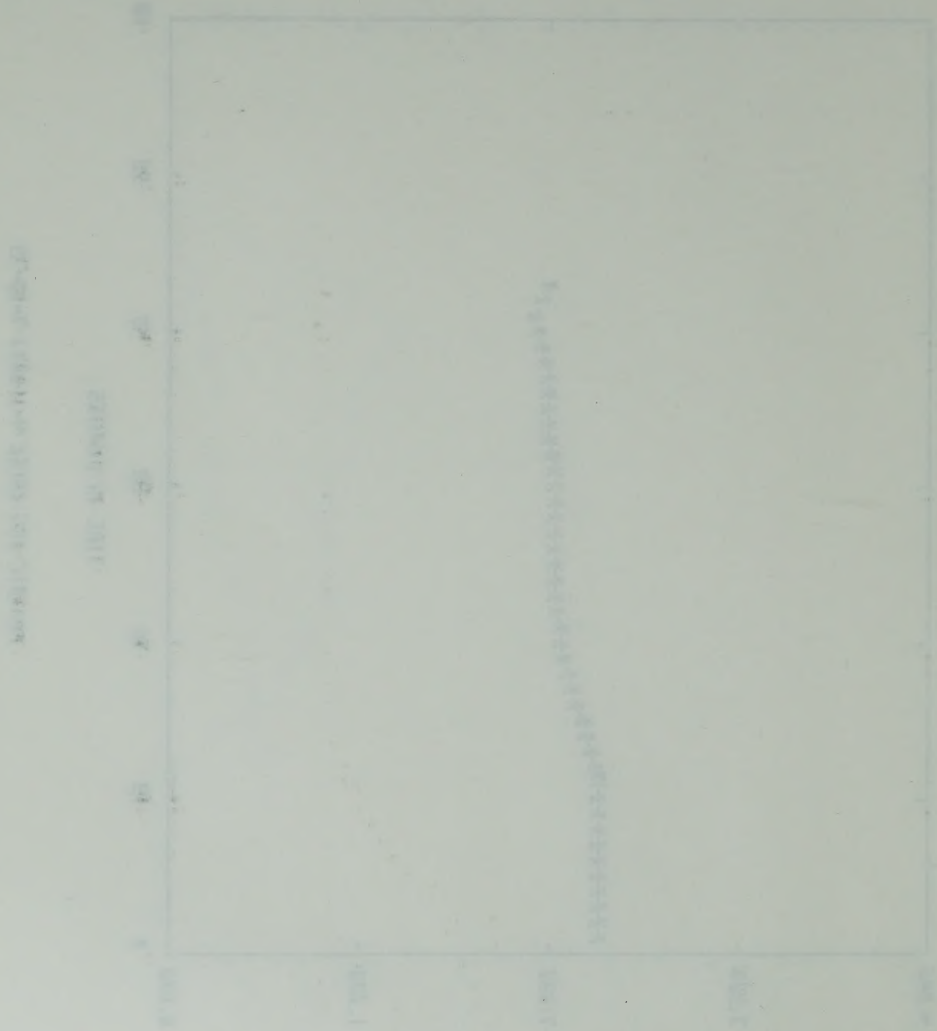
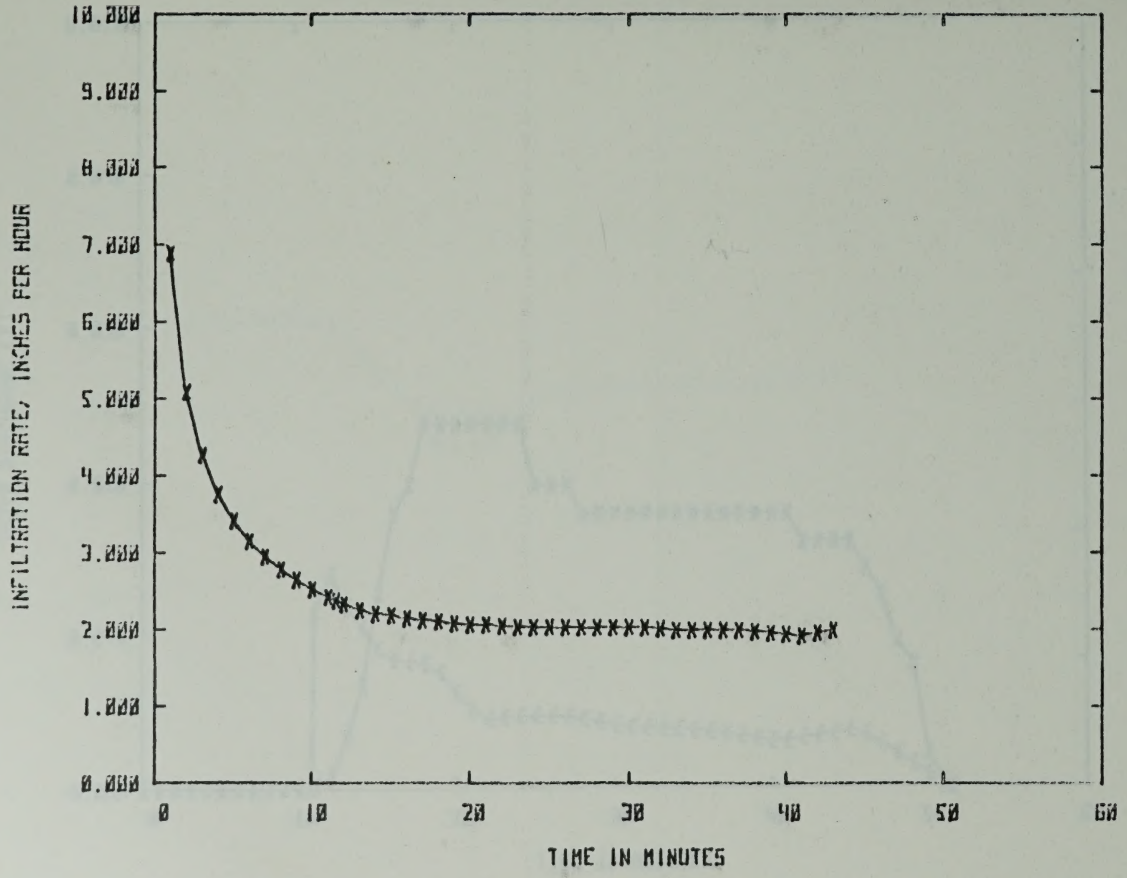
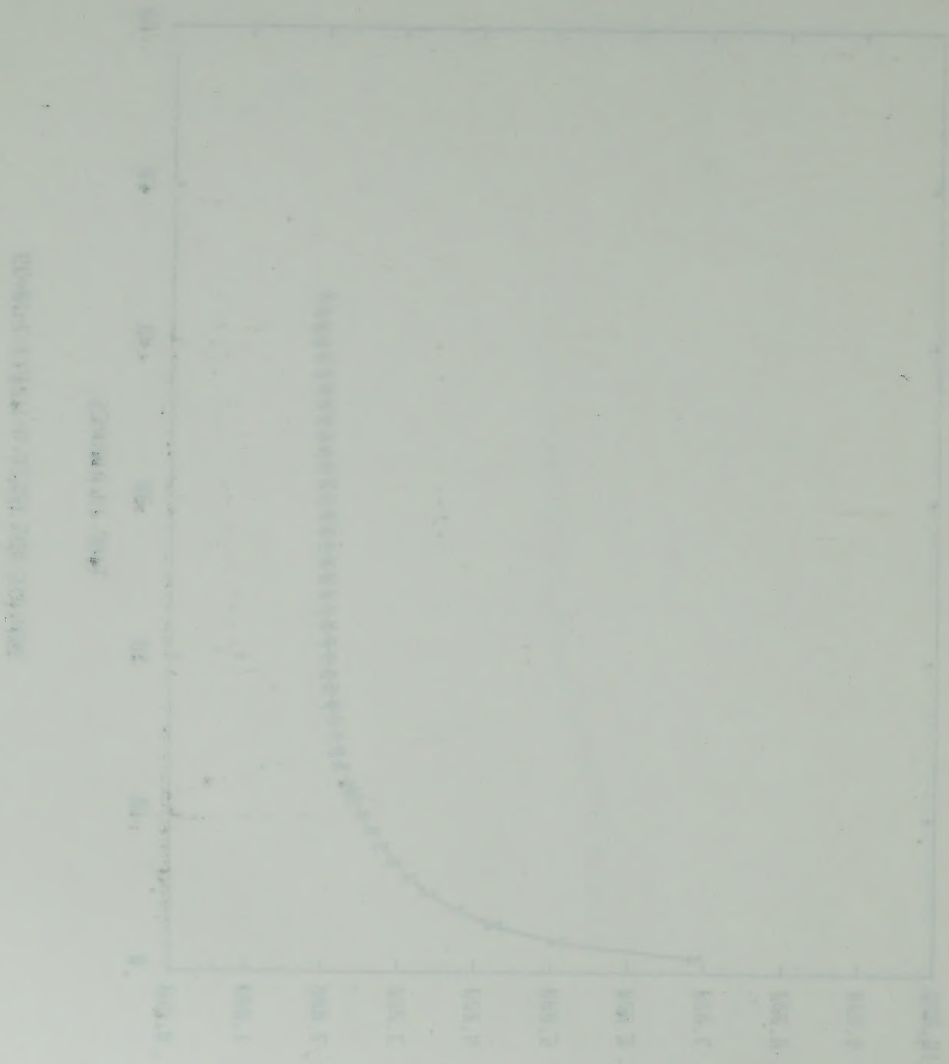
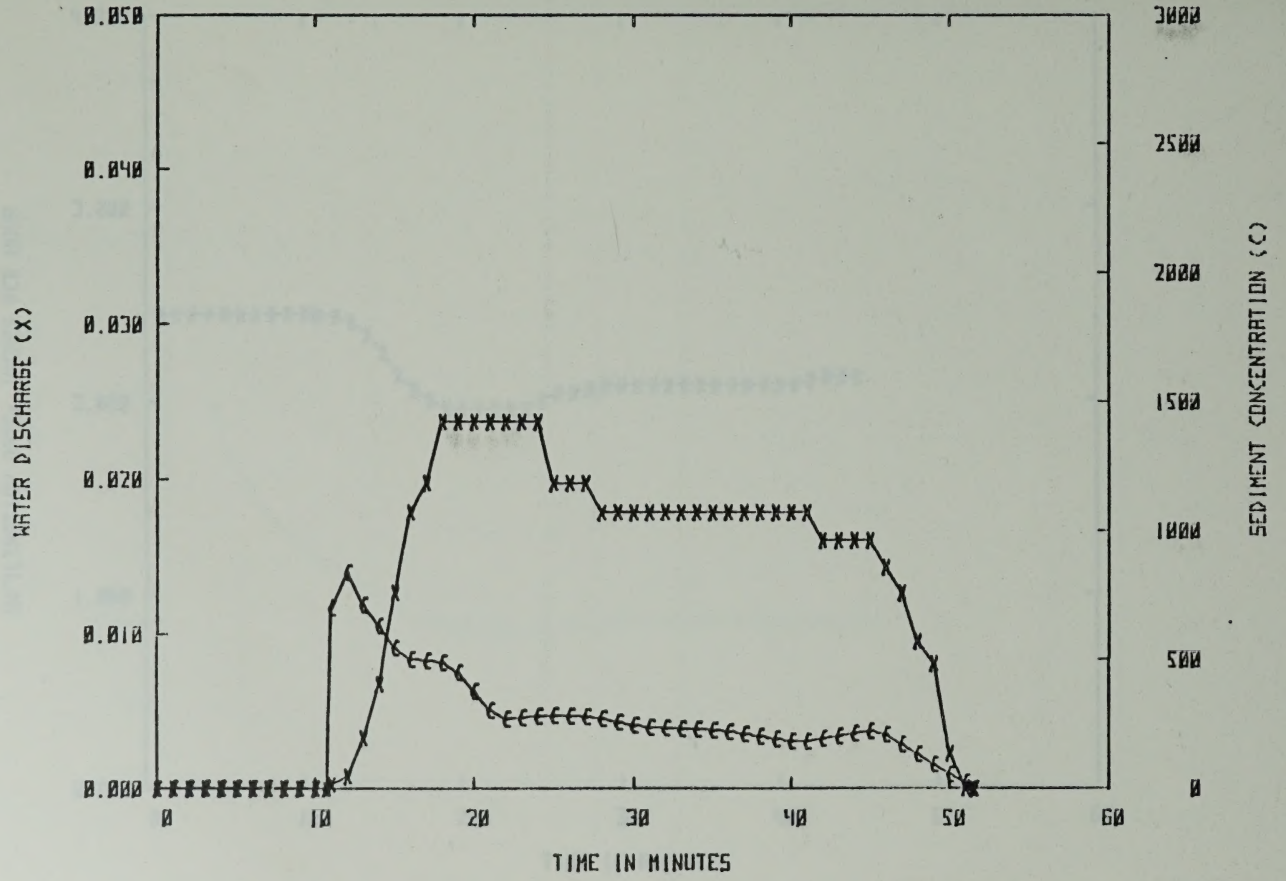


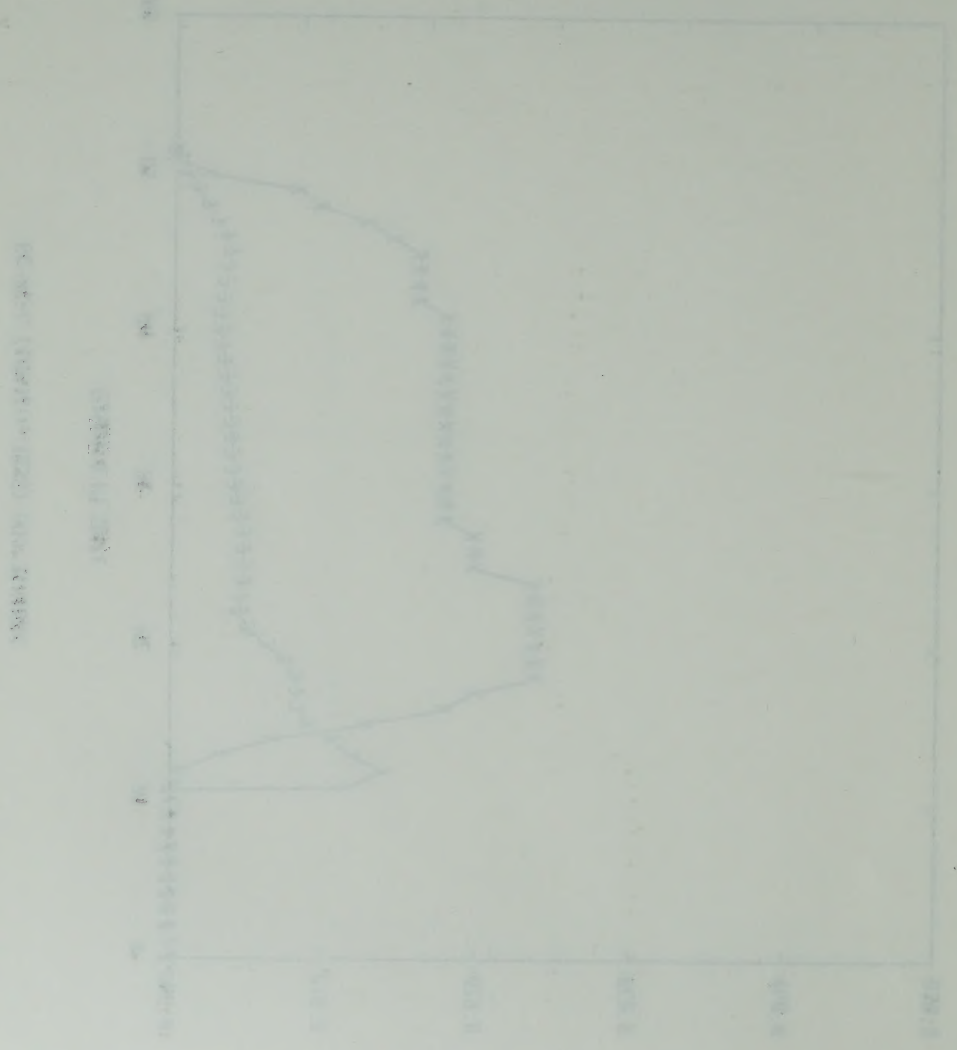


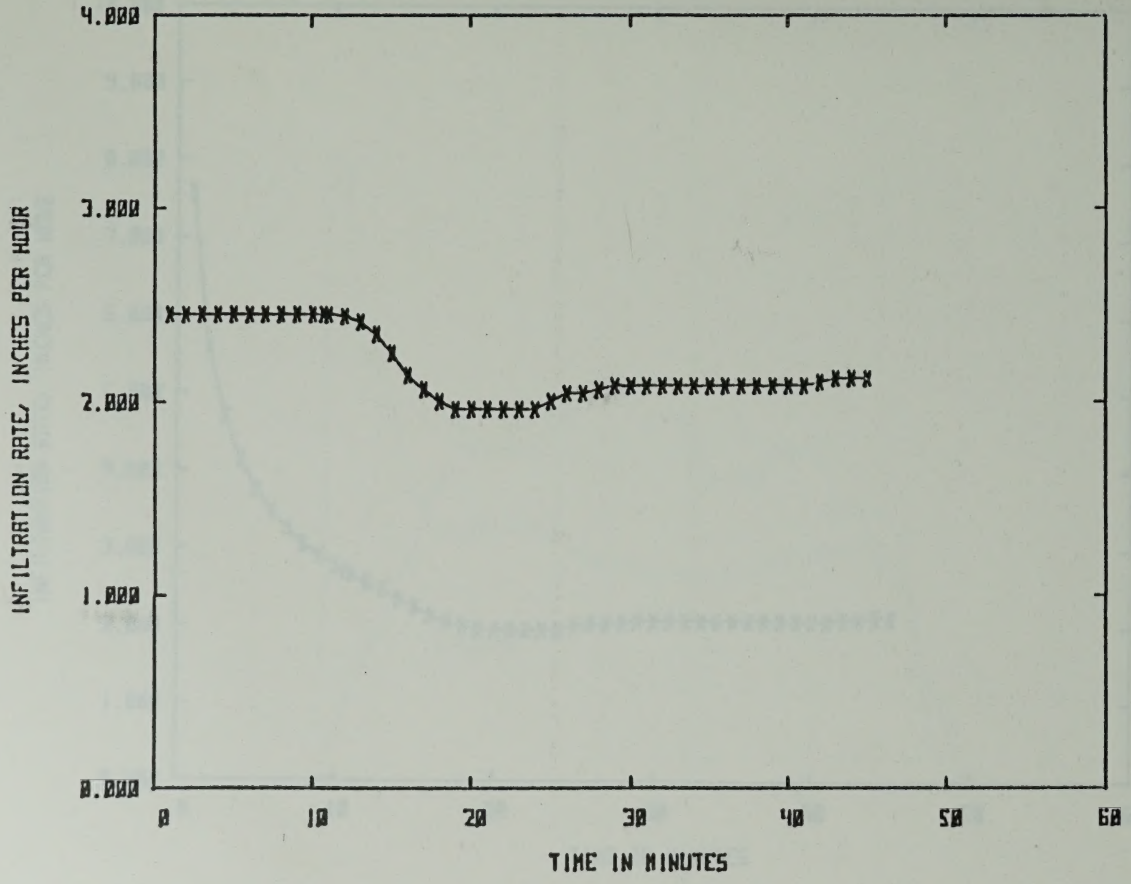
PRAIRIE DOG CREEK 4-1(DRY) 7-10-79



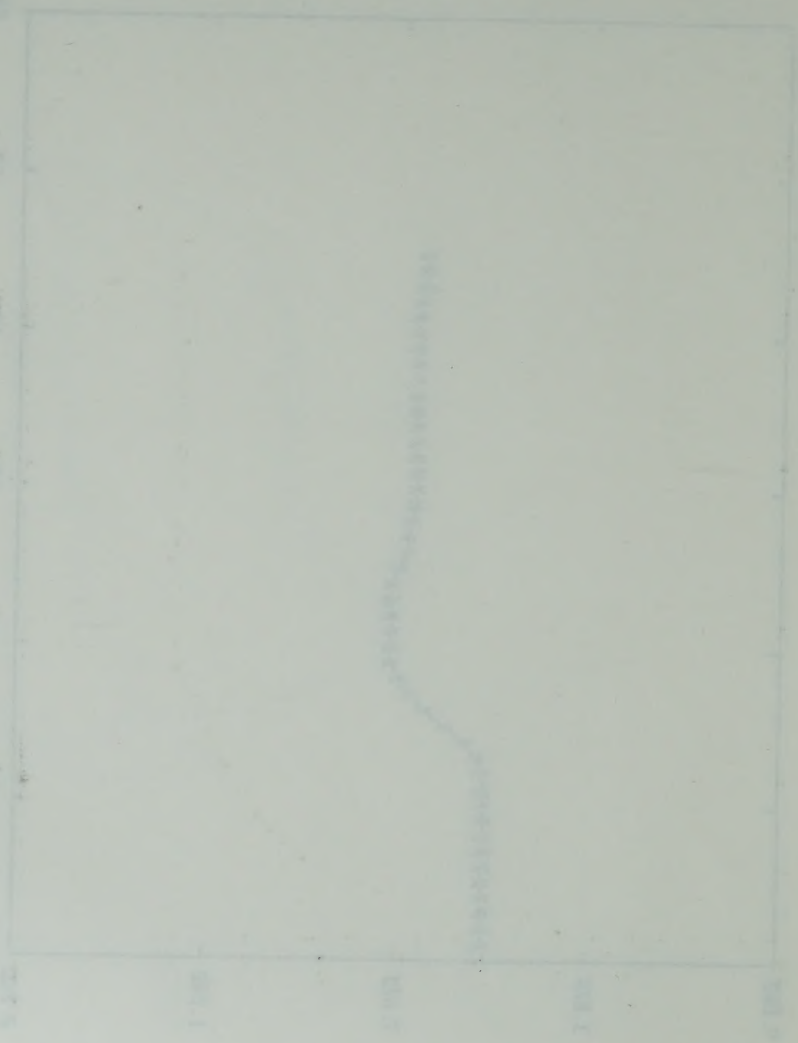


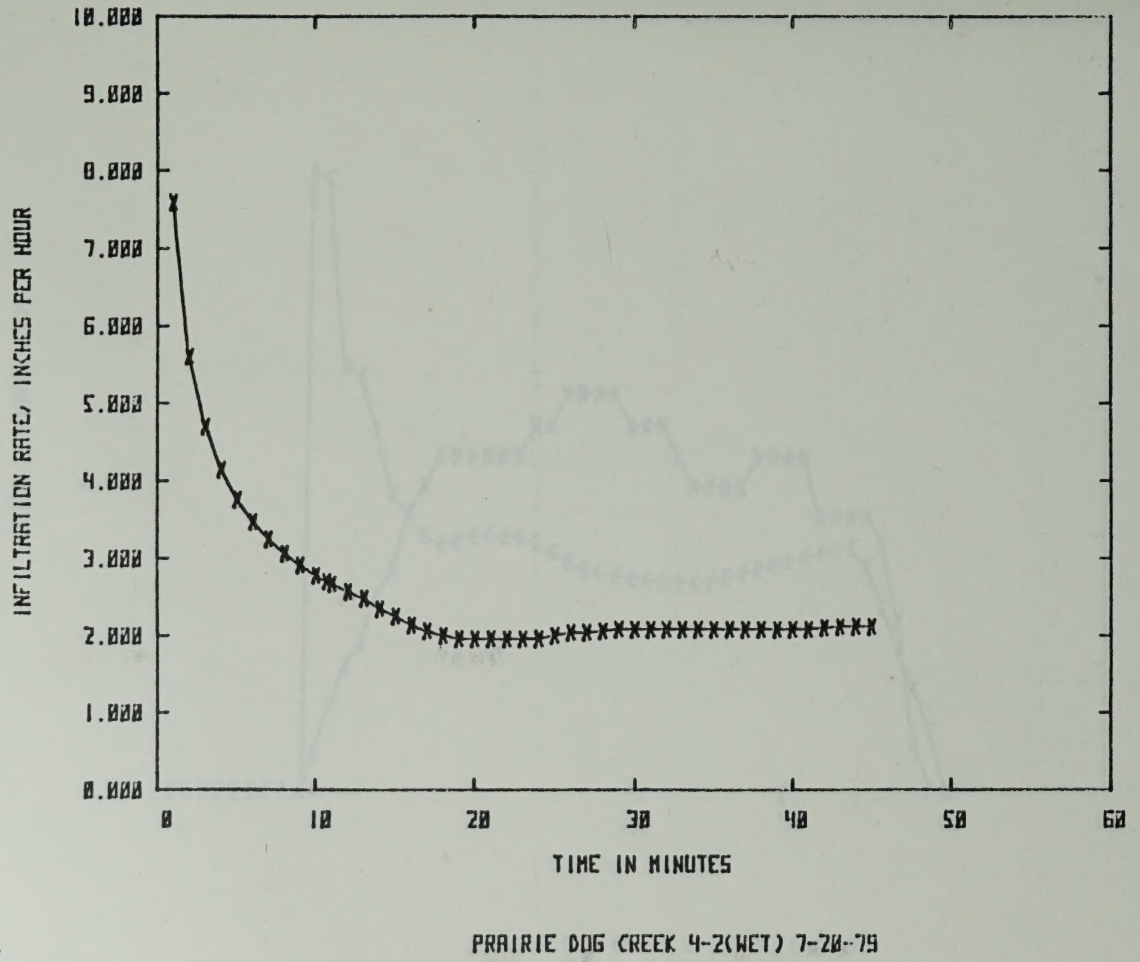
PRAIRIE DOG CREEK 4-2(WET) 7-20-79



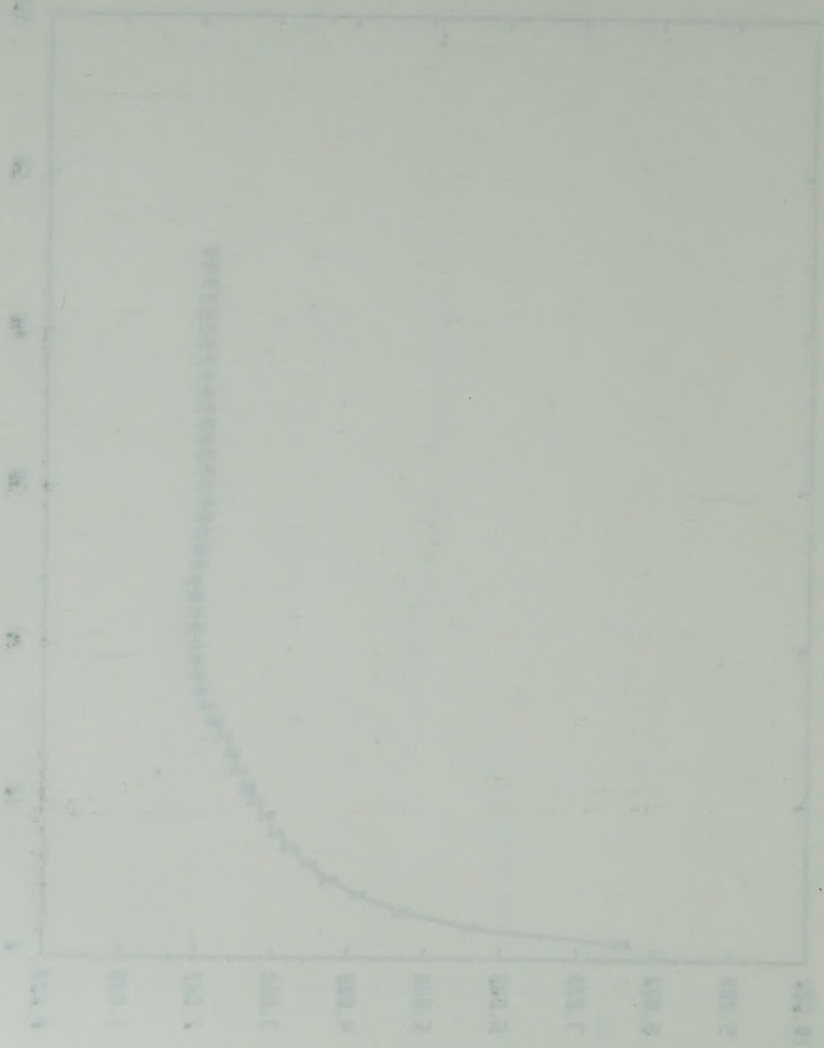


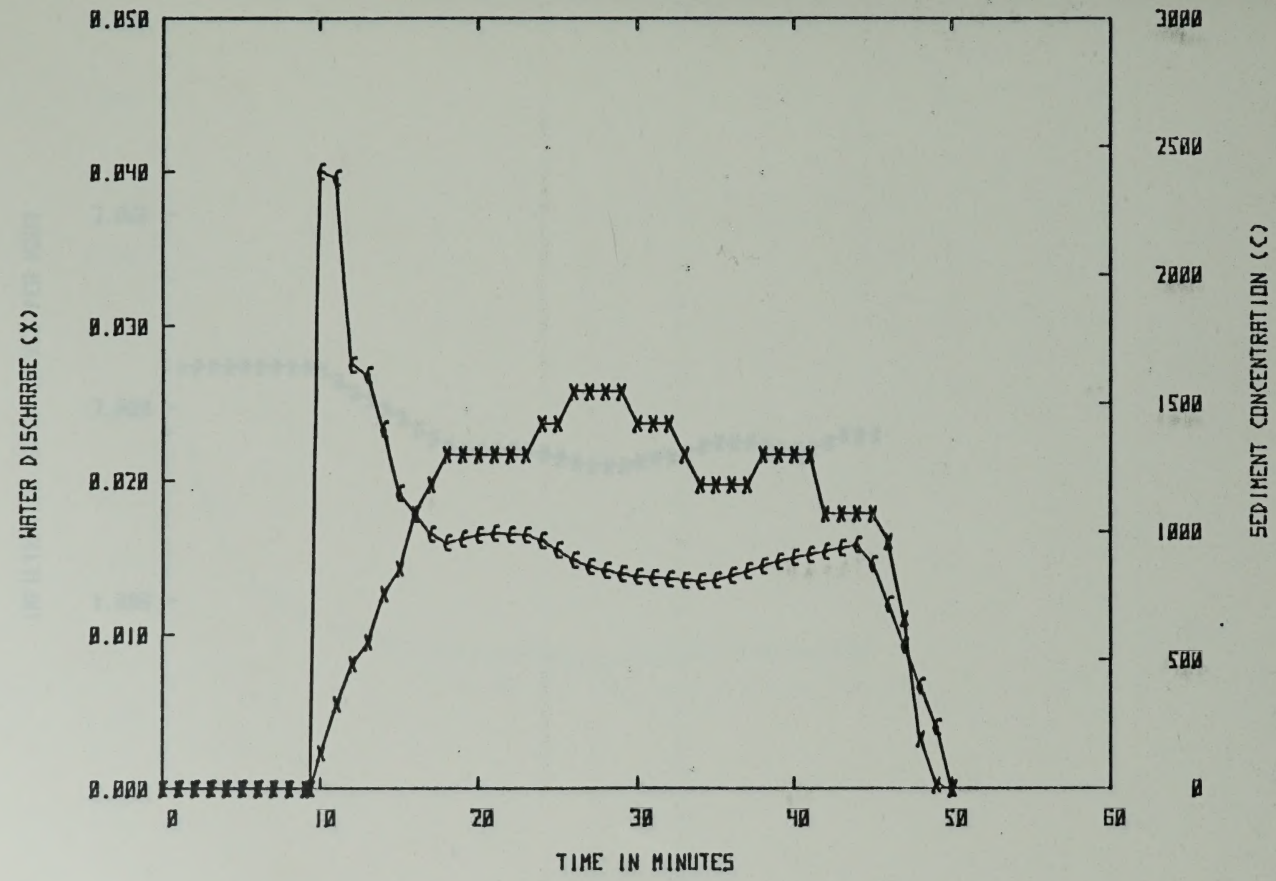
PRAIRIE DOG CREEK 4-2(WET) 7-20-79



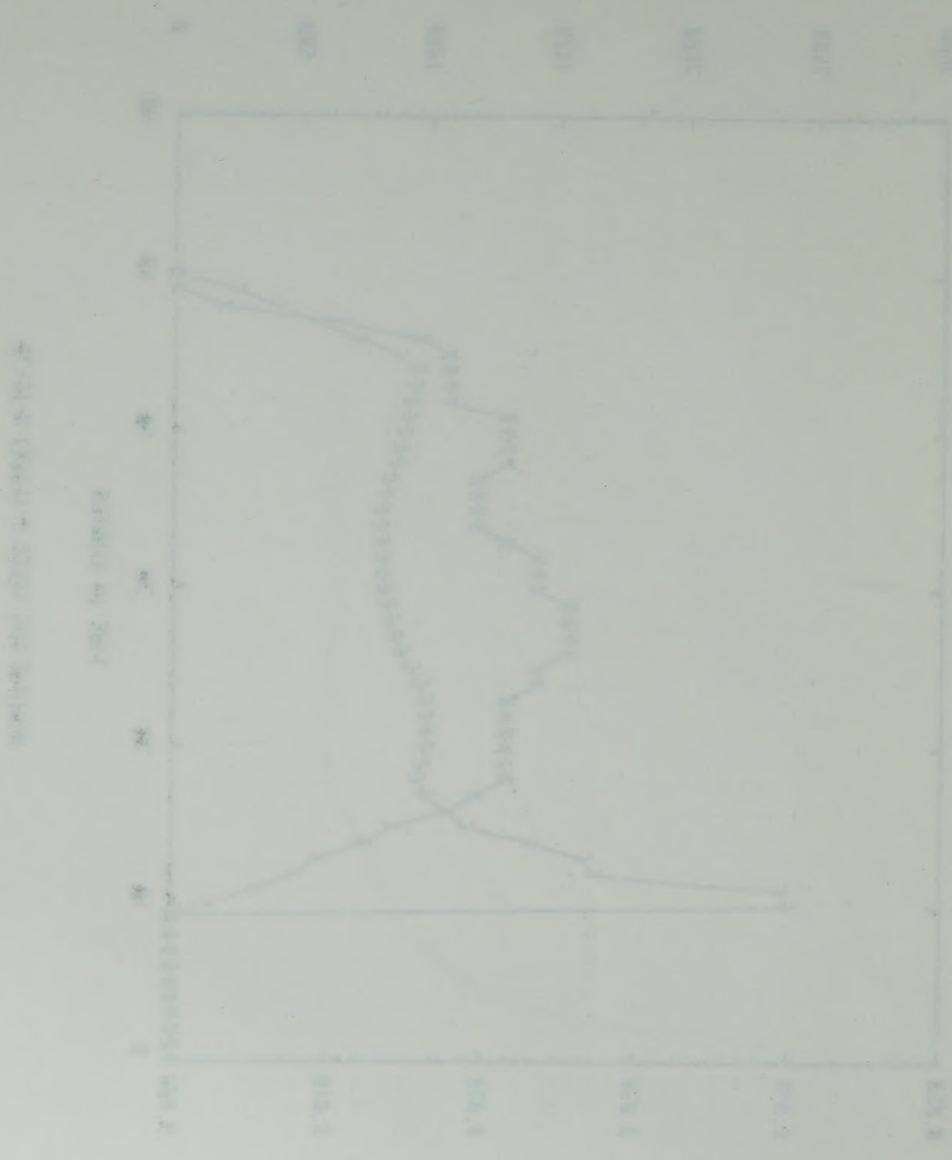


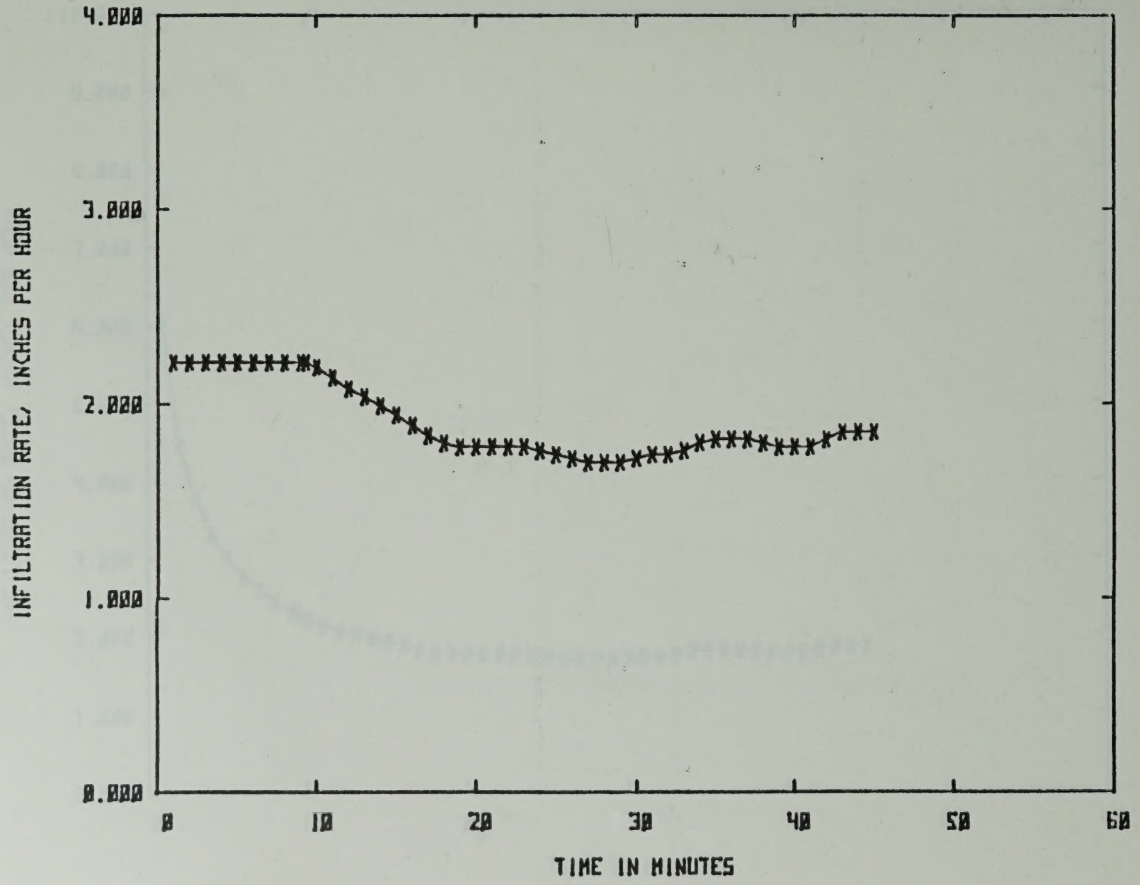
PRAIRIE DOG CREEK 4-2(WET) 7-20--79



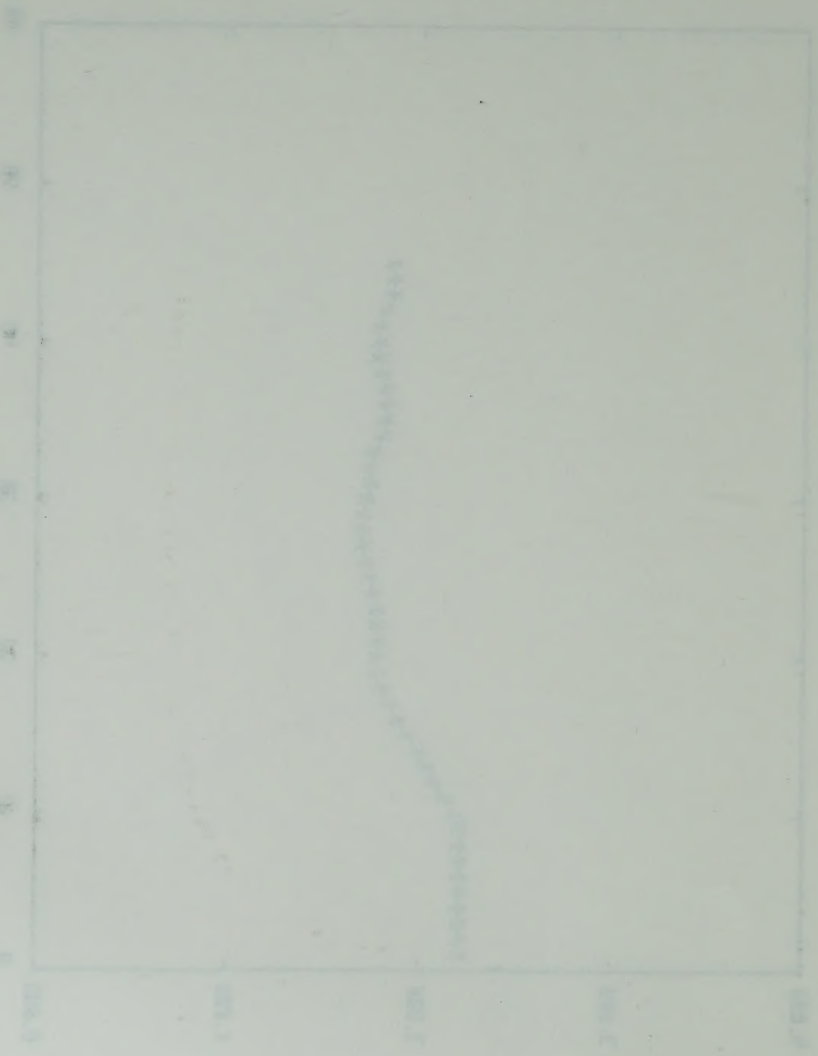


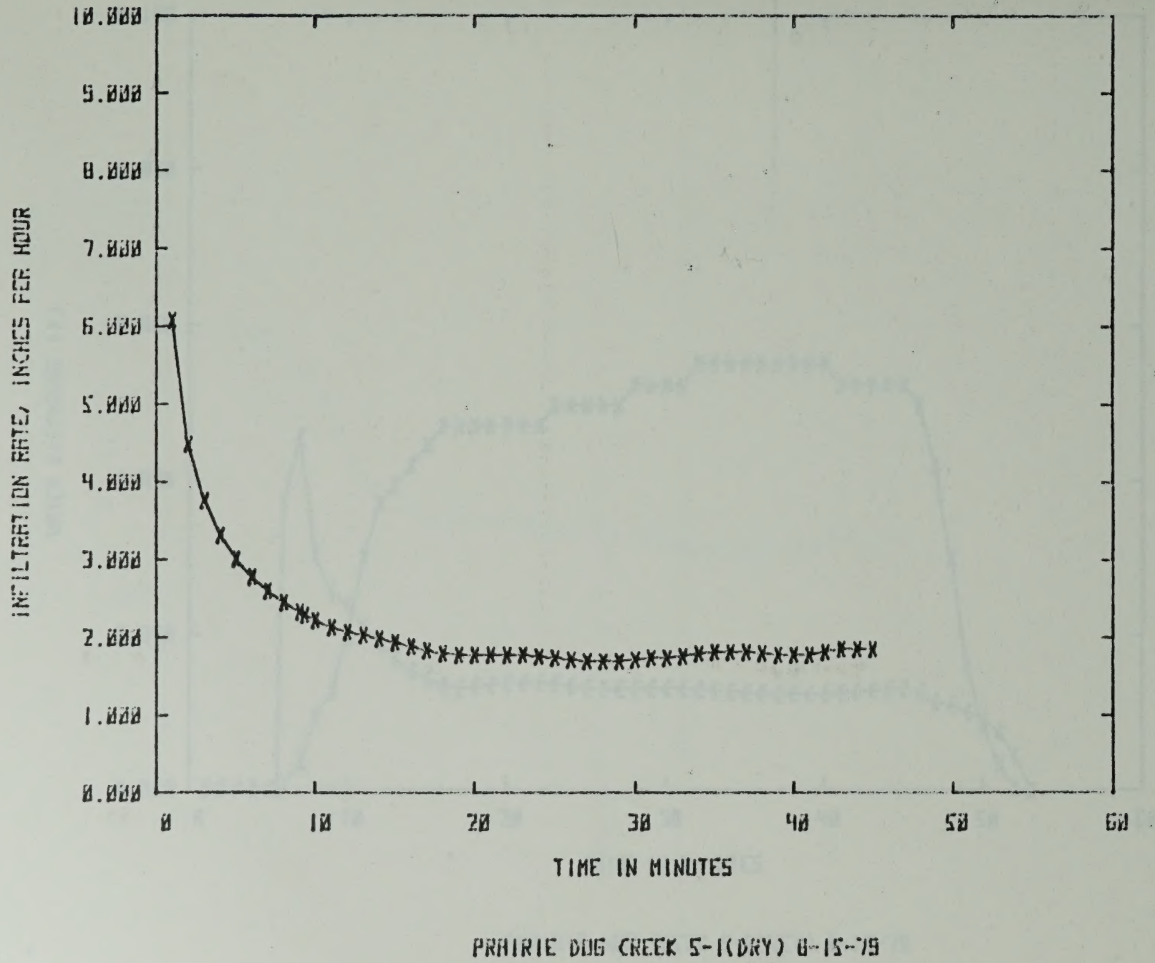
PRAIRIE DOG CREEK S-1(DRY) 8-15-79



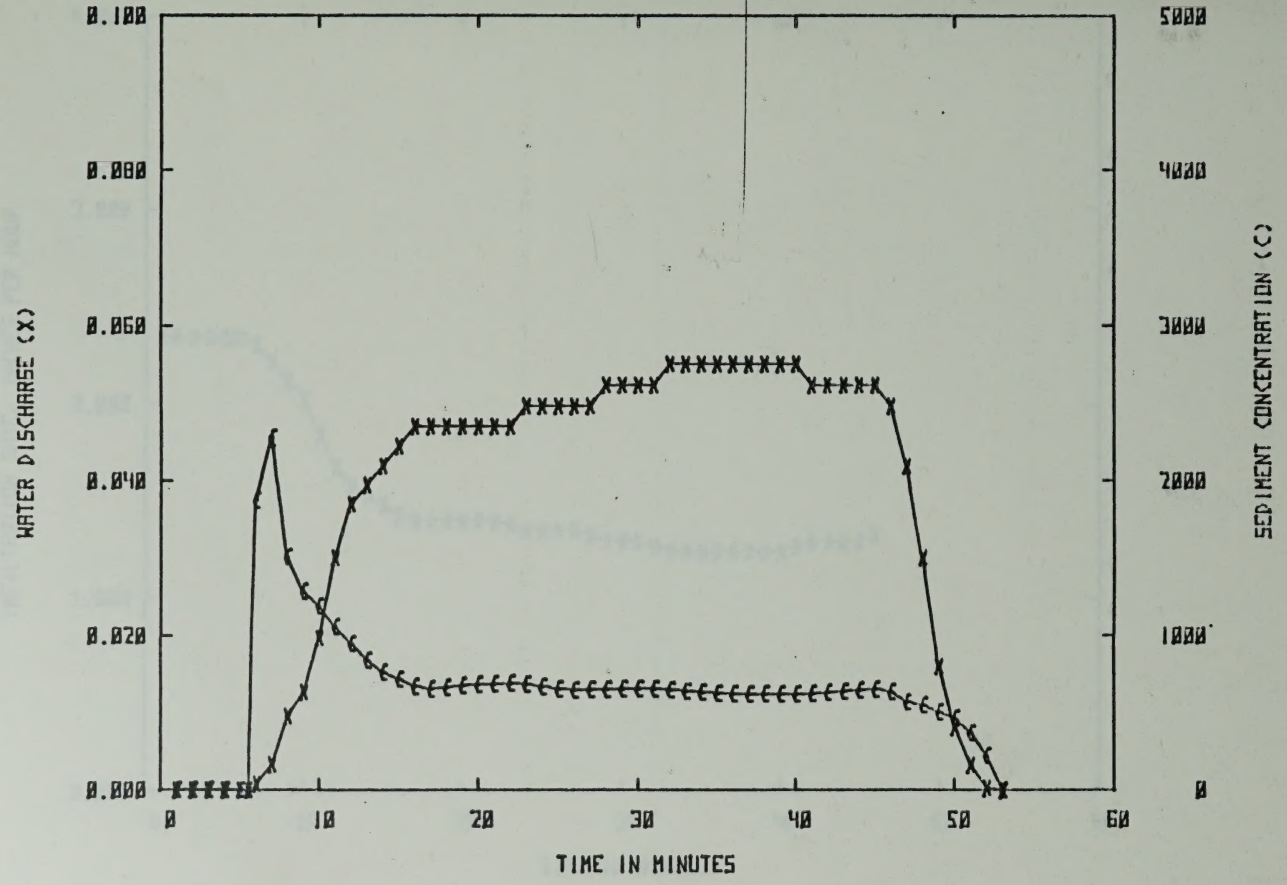


PRAIRIE DOG CREEK S-1(DRY) 8-15-79

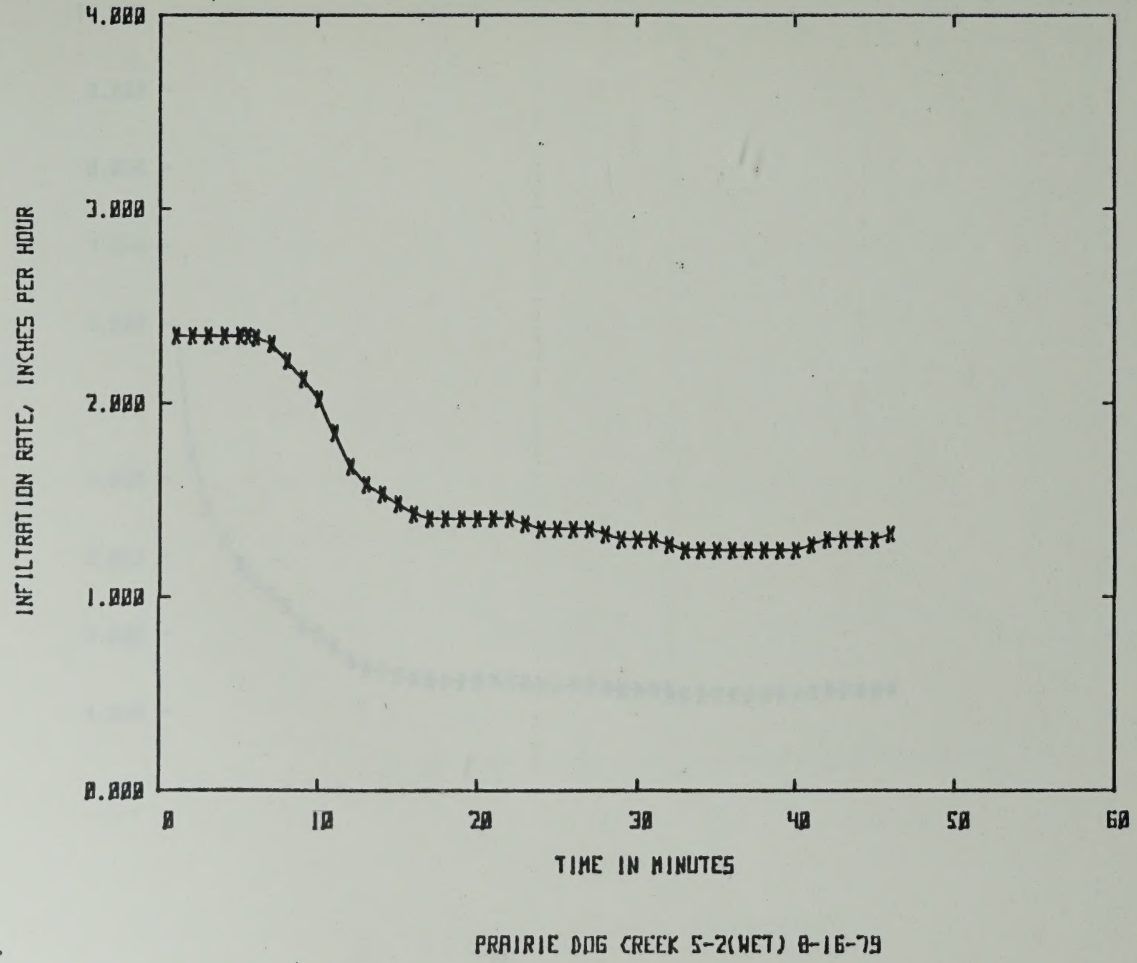




PRAIRIE DOG CREEK S-1(DRY) 8-15-79



PRAIRIE DOG CREEK S-2(WET) 8-16-79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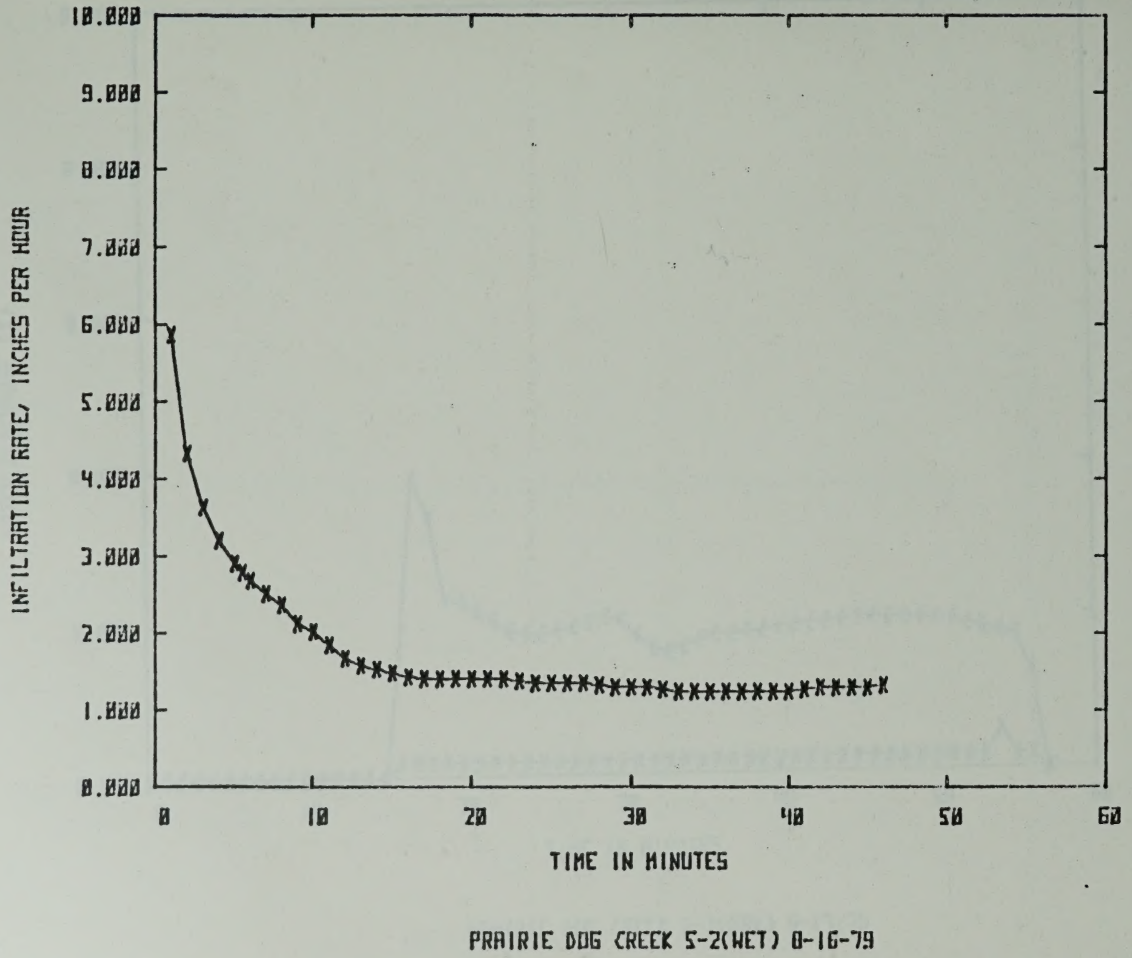
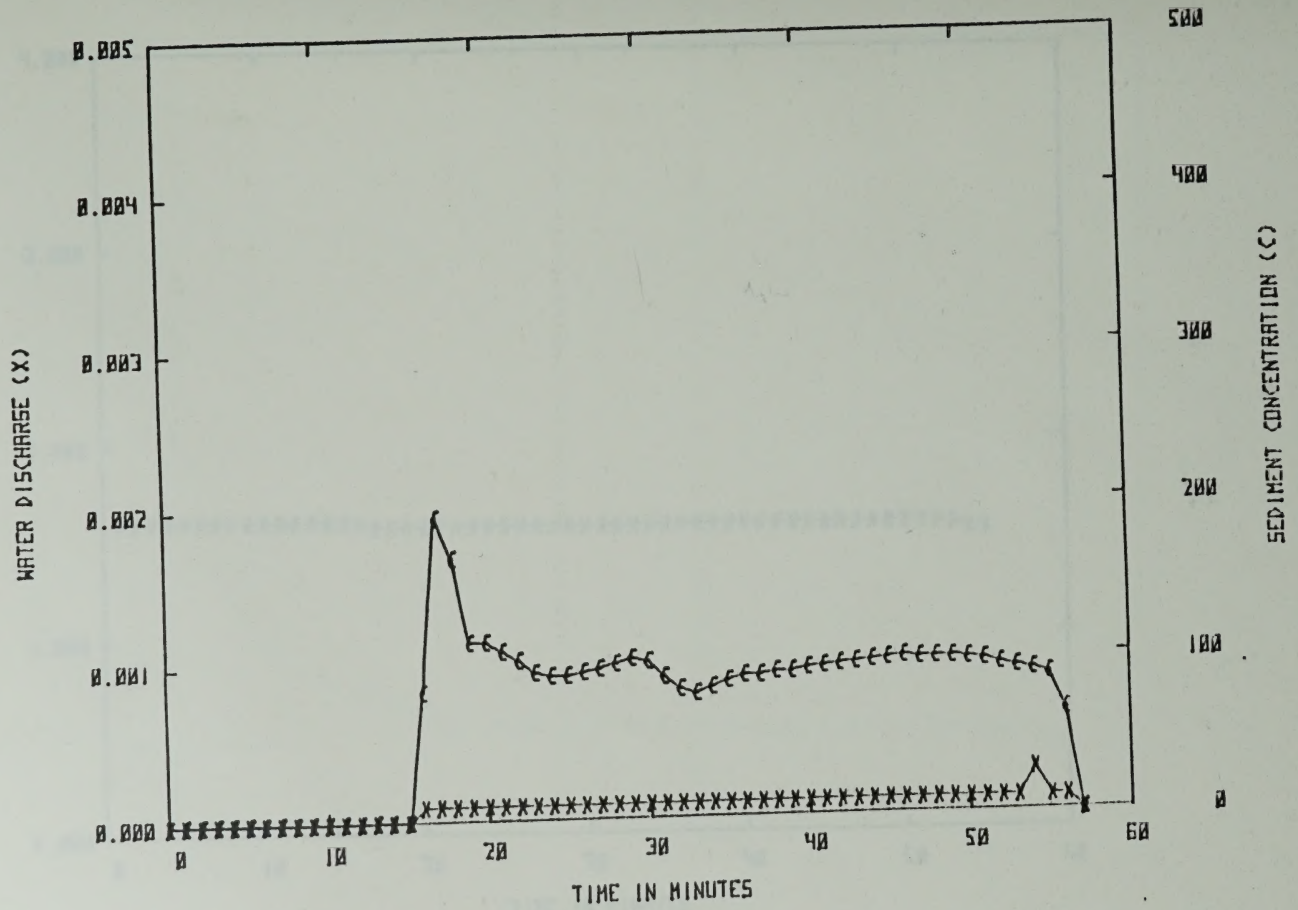
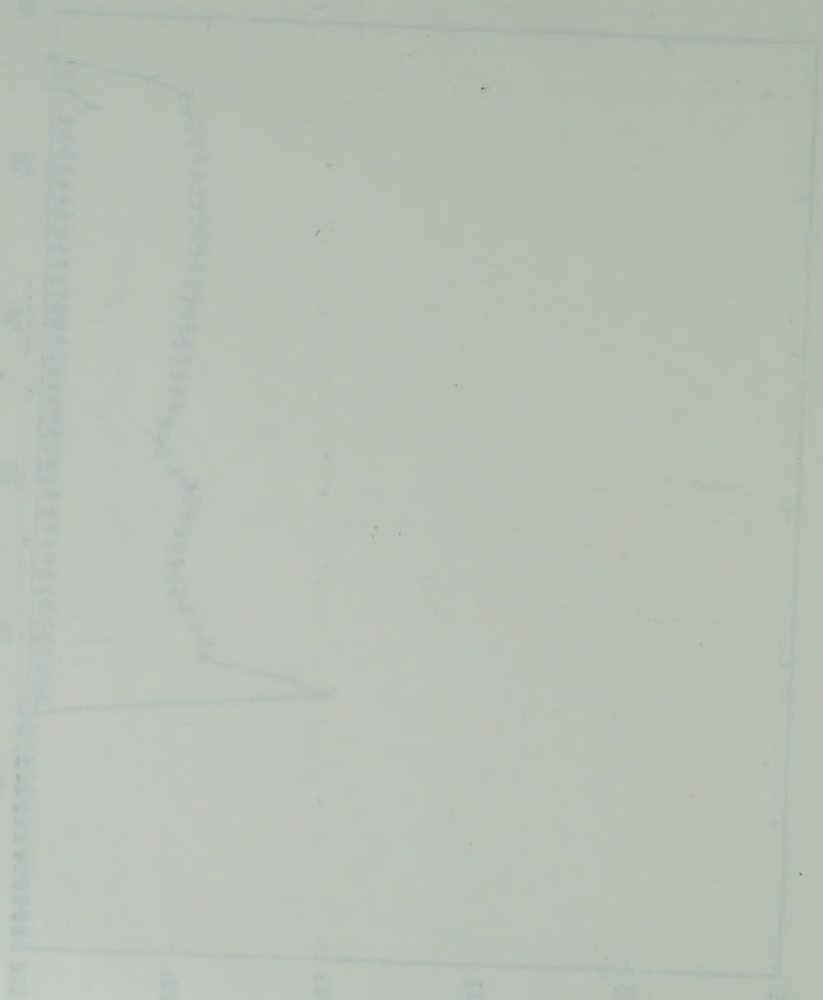
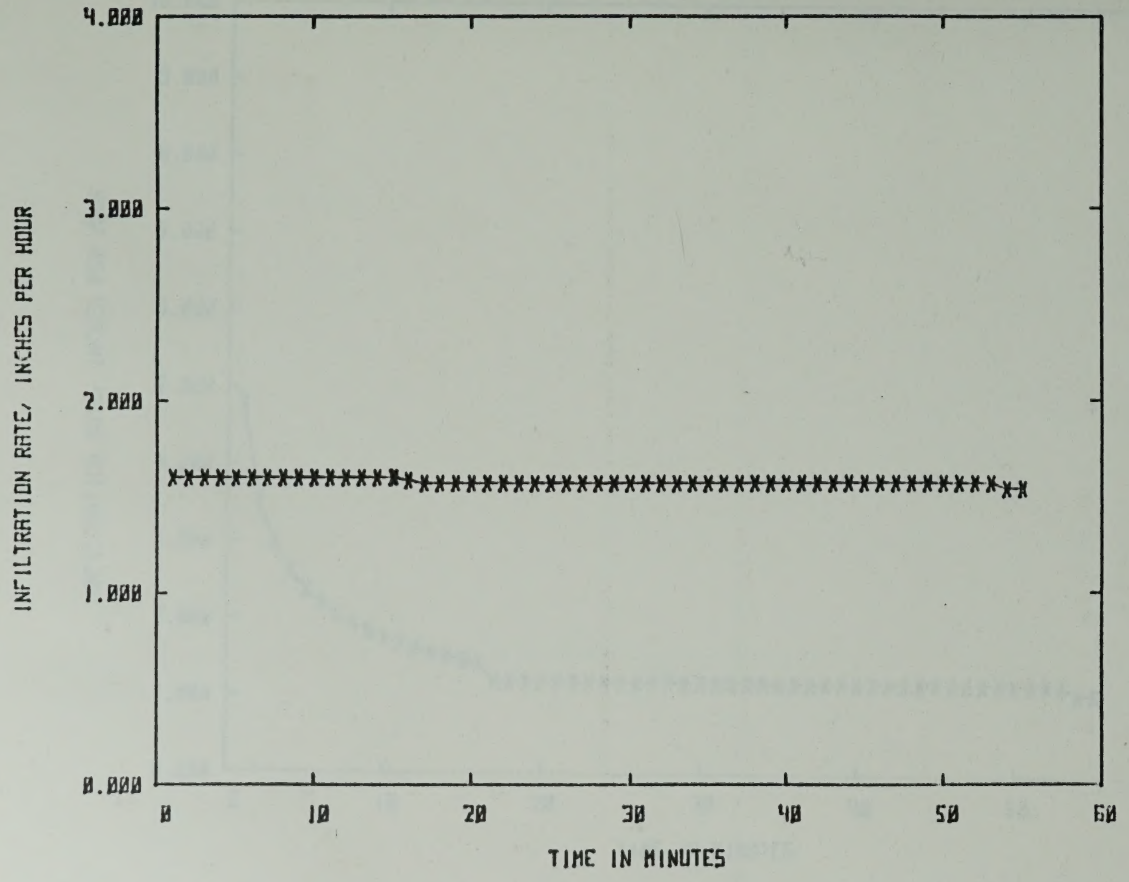
3.000
2.000
1.000
0.000
INFILTRATION RATE, INCHES PER HOUR
0
10
20
30
40
50
60
TIME IN MINUTES
PRAIRIE DOG CREEK S-2(WET) 8-16-79


10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
INFILTRATION RATE, INCHES PER HOUR
0
10
20
30
40
50
60
TIME IN MINUTES
PRAIRIE DOG CREEK S-2(WET) 8-16-79

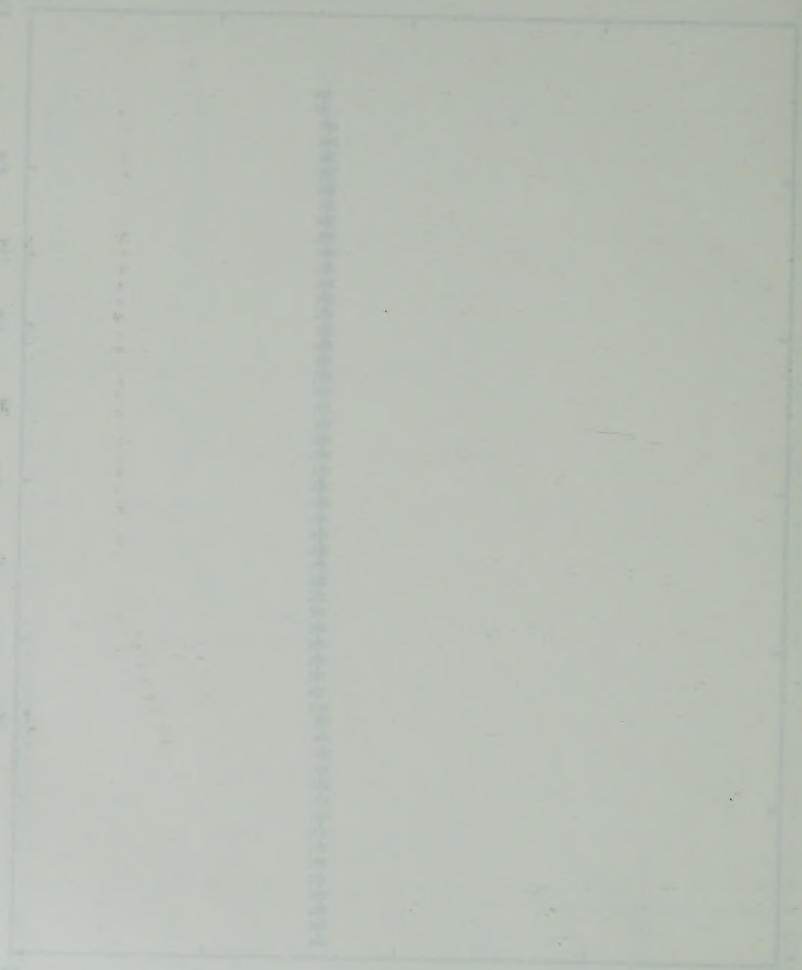


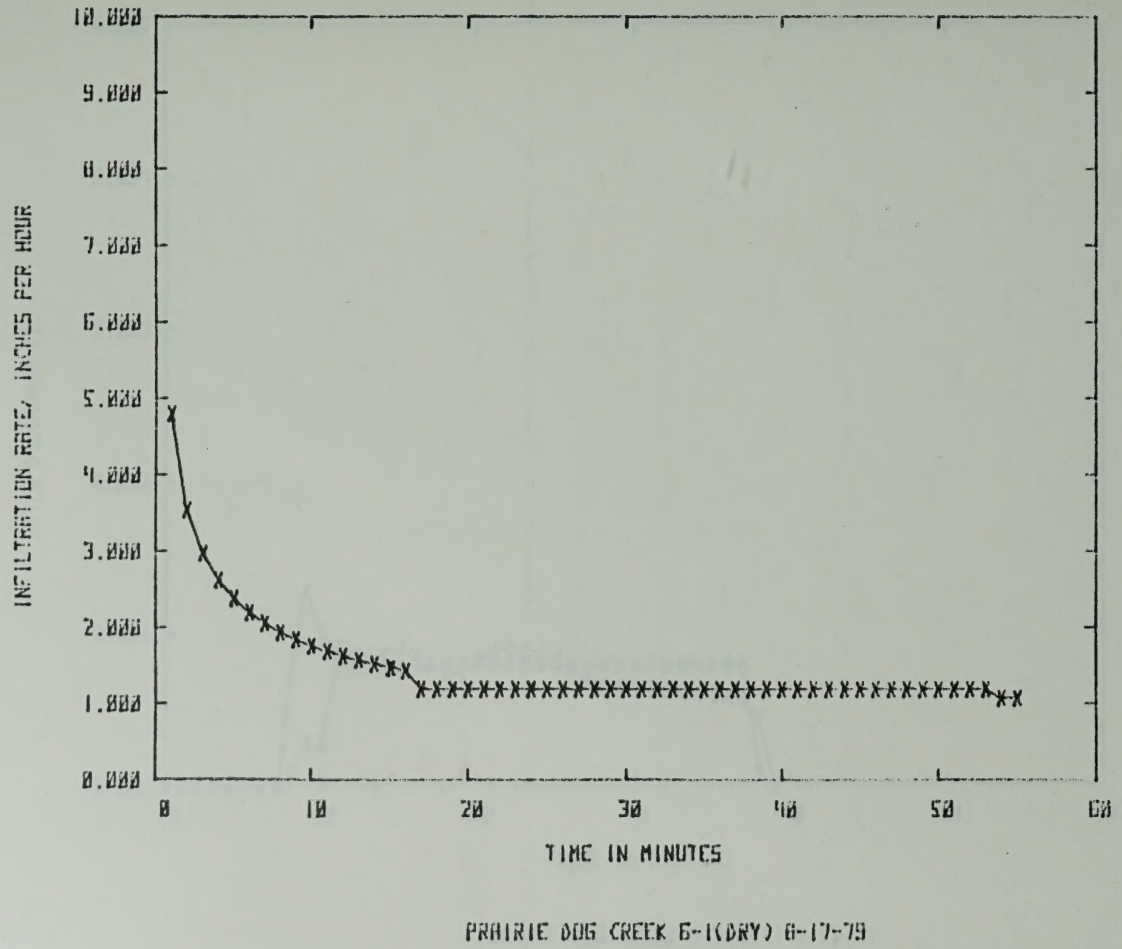
PRAIRIE DOG CREEK G-1(DRY) 8-17-79



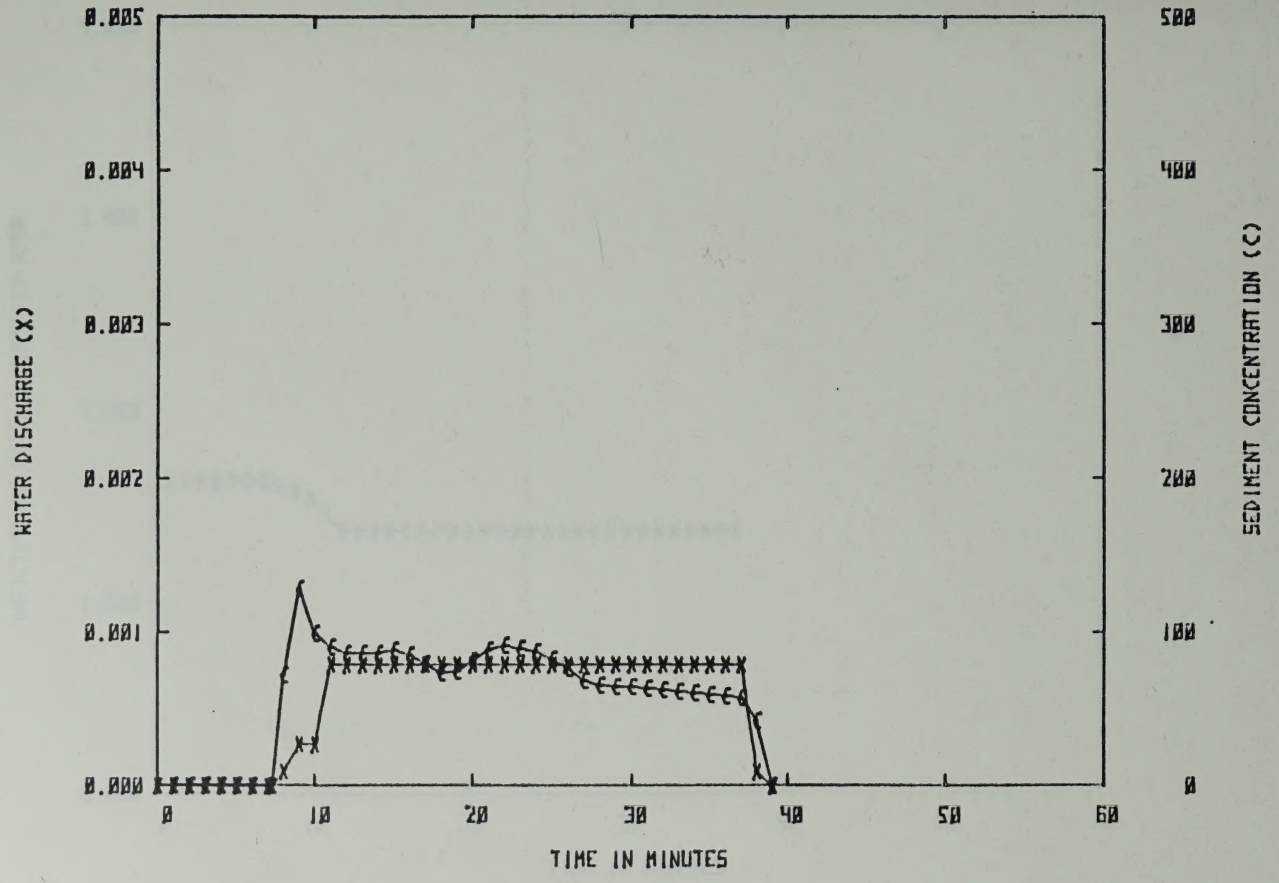


PRAIRIE DOG CREEK G-1(DRY) 8-17-79

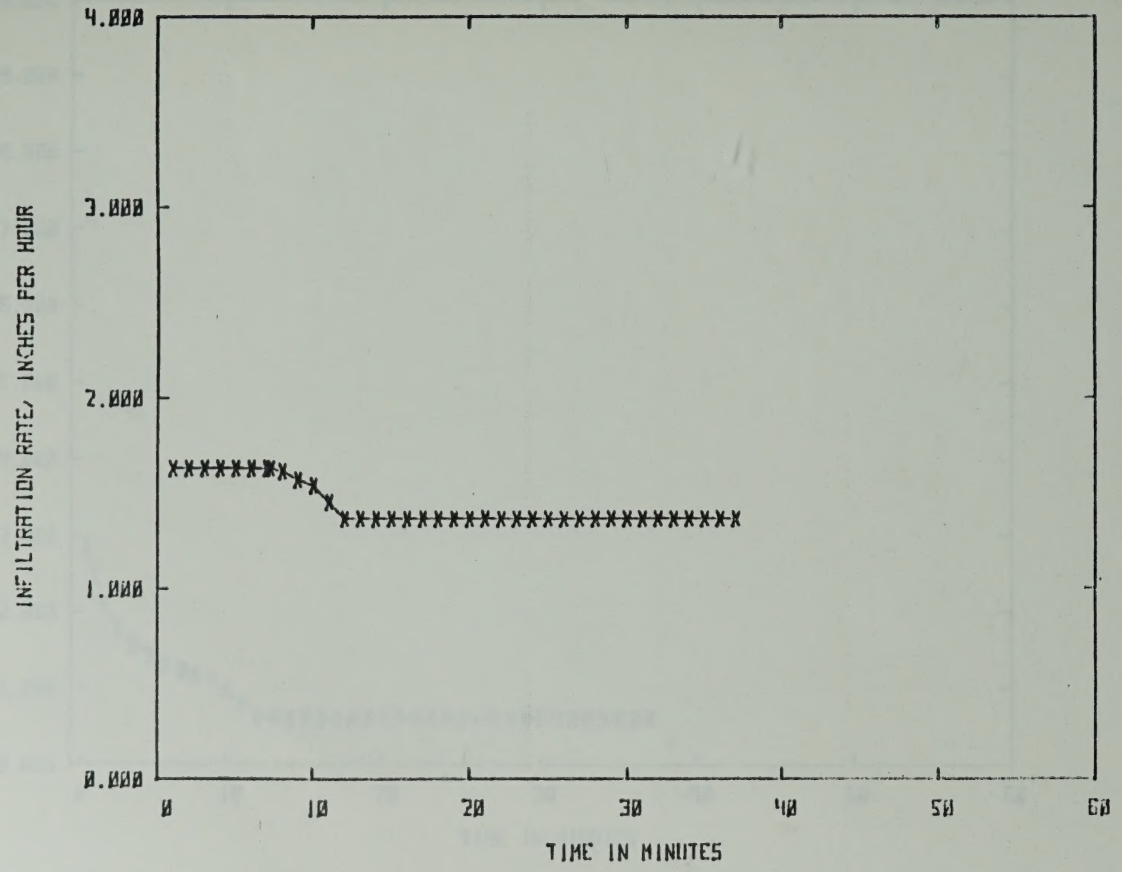




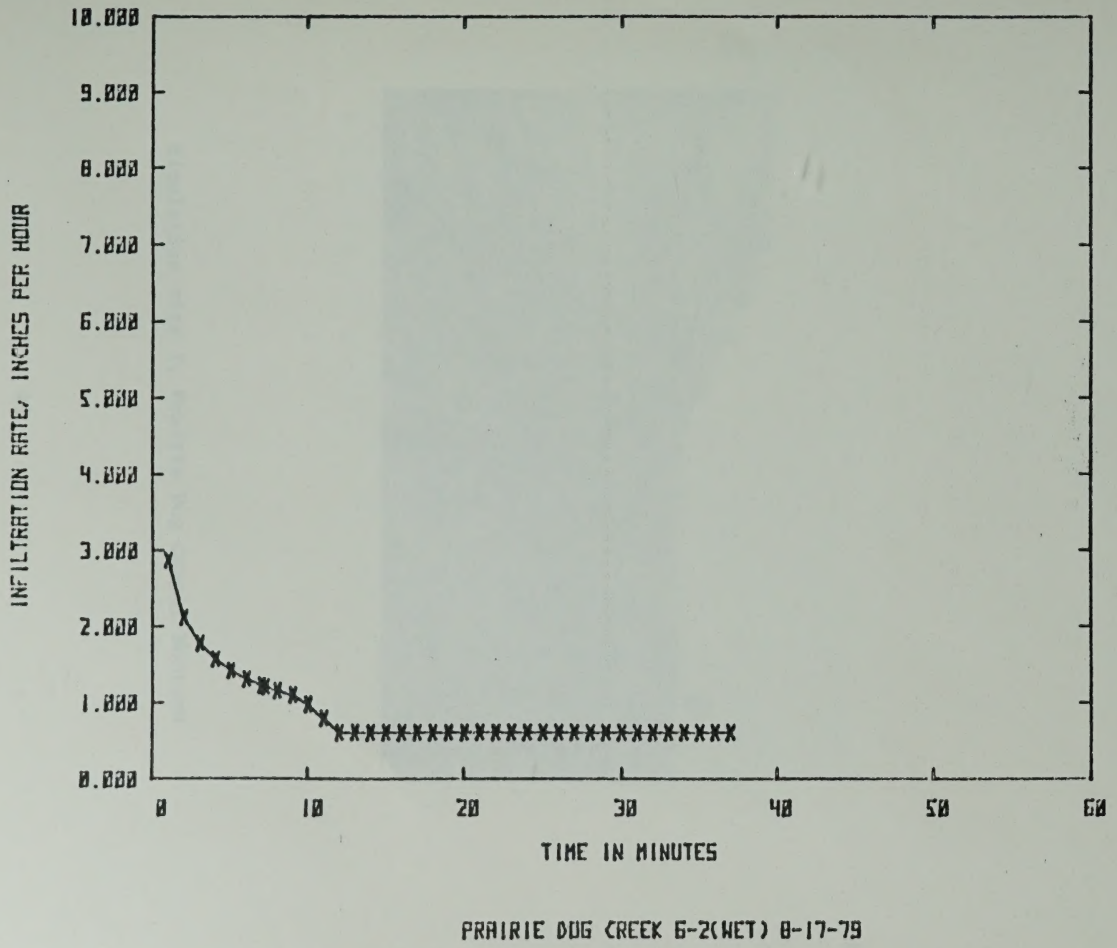
PRAIRIE DOG CREEK G-1(DRY) 6-17-79



PRAIRIE DOG CREEK 6-2(WET) 8-17-79



PRAIRIE DOG CREEK 6-2(WET) 8-17-75



PRAIRIE DOG CREEK G-2(WET) 8-17-79

Simulation site 1, Prairie Dog Creek, Montana

Simulation site 2, Prairie Dog Creek, Montana

Simulation site 3, Prairie Dog Creek, Montana

Simulation site 4, Prairie Dog Creek, Montana

Simulation site 5, Prairie Dog Creek, Montana

Simulation site 6, Prairie Dog Creek, Montana

1 enclosure (map)

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Map of Prairie Dog Creek Basin showing location of rainfall simulator sites and vegetative types.

Base from U.S. Geological Survey Taintor
Desert and Birney SW. 7 ½ minute quadrangles

1 enclosure (map)